ON THE EDGE OF THEIR SEATS: A HUMAN-CENTRED APPROACH TO PRIMARY SCHOOL CHAIR DESIGN

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Abstract

This research will contribute to a small but increasing body of knowledge in design-related research specifically for primary school furniture and will be of significance to those in design, education, ergonomics and the school furniture industry.

School chairs connect pupils with the surrounding classroom environment and are, therefore, a vital factor in providing appropriate physical support for children to learn in comfort. Evidence indicates that this is not the current state-of-affairs. Studies show that school furniture, including chairs, does not provide a good physical fit for pupils and this is a contributory factor in children reporting back problems. So, apart from being uncomfortable to use, badly fitting school chairs could be detrimental to children’s long-term wellbeing.

The aim of this design practice-based research was to find ways of contributing to children’s long-term wellbeing by improving the design of primary school chairs. On the face of it, this appeared to be a straightforward design problem. However, taking this view is too simplistic because the chair exists in a social environment affecting all aspects of its being. This real world setting holds clues to addressing the design problem. A multi-stakeholder and participatory approach has been used to explore furniture design issues within the real world setting of a working classroom. Ethically approved, field research used qualitative, ethnographic based methods.

Insights from the field have been used to test a design concept for school chairs with greater relevance for those in primary education. However, research findings also demonstrate that the archetypal school chair is an inappropriate design for primary school users and identifies why design alone will not alter the status quo. Social and cultural factors as well as the design affect the way that children use chairs in school and both need to alter for any real change to take effect.
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List of Acronyms and Abbreviations

A&H CREC [University of Brighton’s] Arts & Humanities College Research Ethics Committee

BAG der Bundesarbeitsgemeinschaft für Haltungs- und Bewegungsförderung [Federal Working Group for Posture and Movement Promotion]

BERA the British Educational Research Association
BSF Building Schools for the Future
CAD Computer-aided design
CFG Counties Furniture Group
DfE Department for Education
DfES Department for Education and Skills
EFA Education Funding Agency
ESRC Economic and Social Research Council
FIRA Furniture Industry Research Association
FREGC [University of Brighton’s] Faculty [of Arts] Research Ethics and Guidance Committee
HCD Human-centred design
HSE Health and Safety Executive
ICT Information and Communications Technology
ISO International Organisation for Standardisation
PCP Primary Capital Programme
PSBP Priority School Building Programme
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Authors Declaration

I declare that the research contained in this thesis, unless otherwise formally indicated within the text, is the original work of the author. The thesis has not been previously submitted to this or any other university for a degree, and does not incorporate any material already submitted for a degree.

Signed

Dated
Chapter 1: Introduction

Schools can be seen as physical and bureaucratic constructions influencing children’s lives through forming a part of the “material culture of childhood” (Dudek, 2005, p.vii). In January 2015 there were 4,510,308 pupils in English state-funded primary schools (Data.gov.uk, 2015). That each child has a school chair available to them could be indicative of the value placed on education and could also be interpreted as symbolic recognition of their individuality (Cullis, 2010, p.65). However, what value is being expressed if that chair is a general purpose, low cost product with a design provenance in the last century? Where is the recognition of the individuality of those children if classrooms full of pupils of different sizes, all growing at different rates, are provided with chairs on a one-size-fits-all basis?

1.1 Outline of the design problem

Ergonomic research has found school chairs to be a poor physical fit for the pupils using them. (Mandal, 1984; Parcells et al, 1999; Bond et al, 2002; Panagiotopoulou et al 2004; Gouvali & Boudolos, 2006; Saarni et al 2007a; Brewer et al, 2009) and this has been recognised as a factor contributing to children reporting back problems (Murphy et al, 2007). So, apart from being uncomfortable to use, badly fitting school chairs could be detrimental to children’s long-term wellbeing.

The issue was addressed in part by the publication of a new British and European Standard (BSI, 2007) for school furniture in 2006. Part 1 sets out functional dimensions for school furniture and took into account increases in the sizes of children, using anthropometric data from five European countries. The range of sizes catered for in the current standard ought to mean that every primary school child has a suitable

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1 Part 1 was updated on 31st December 2015. Part 2 (BSI, 2012) deals with safety requirements and testing methods
chair that fits but, as the thesis will demonstrate, an apparent physical fit on paper does not guarantee that the design is fit for purpose. Furthermore it will argue that the effectiveness of a school chair is affected as much by social and cultural values as by its design.

As a designed object the educational chair has been left far behind the office chair that is arguably its closest relative. Olivares (2011) classifies a progression of office chair features in presenting 132 different designs dating from 1853 until 2009. Each chair represents the introduction of a new feature in the design and manufacture of office seating. Collectively they tell a story about new manufacturing methods and materials and also of changing attitudes to ergonomic expectations, the social organisation of the workplace and of an all-round recognition that the people using the chairs are individuals (p.25). The same cannot be said of school chairs. Comparative development has been slow and, although the design of furniture has altered to suit new approaches to education, there have been no recent, significant changes. In April 1899, Dewey spoke about the difficulty of finding school furniture to suit the needs of children working at school:

“Some few years ago I was looking about the school supply stores in the city, trying to find desks and chairs which seemed thoroughly suitable from all points of view - artistic, hygienic, and educational - to the needs of the children. We had a great deal of difficulty in finding what we needed, and finally one dealer, more intelligent than the rest, made this remark: “I am afraid we have not what you want. You want something at which the children may work; these are all for listening.” That tells the story of the traditional education.” (Dewey, 2008, p.21).

This thesis maintains that the same appraisal can be made of primary schools chairs in use today, more than one hundred years later. These chairs do not suit the needs of primary school pupils and are currently suspended in time; development is stalled by a lack of awareness of the design deficiencies and perpetuated through a systemic fixation with an outmoded archetype.
By reframing the design problem, and approaching it in a holistic manner, the research will show how educational practices and processes as well as chair design compromise healthier and more natural seated postures that children are inclined to adopt when they are engaged in tasks in school. It will demonstrate how Western views of sitting and chairs are so culturally entrenched they remain unquestioned. This is particularly the case in education where an alternative view of how to sit, based on the real needs of the end users as the first priority, is long overdue. The thesis proposes that school furniture design needs to consider other ways of supporting pupils at work in order to accommodate the wide variety of sizes of pupils that have to use one classroom space. In addition those involved in education need to be made aware of the effects of inadequate furniture provisions and the advantages that would come from choosing products that offer good and appropriate support.

Most importantly, the research will emphasis the value of listening to and incorporating into educational product design the views of end users, and particularly children. It will demonstrate how doing this sheds light on real problems that primary school children face in using school chairs and ways in which these could be addressed. It proposes that a human-centred design approach to primary school chairs can be used to develop new design concepts with potentially greater relevance for the individuals using them in primary education.

1.2 Research aims and objectives
The aim of the research was to find ways to improve the design of primary school chairs for the benefit of children’s long-term wellbeing.

The objectives were to establish the real nature of the design problem by conducting practice-based design research using human-centred methodologies. This was to comprise taking a multi-stakeholder and participatory approach to investigate furniture design issues within the complex social setting of a working classroom. Field research was to use qualitative, ethnographic based methods to gain insights on the
experiences of primary school pupils, their teachers and others associated with the use of school chairs.

Primary school seating was the main object under scrutiny with particular reference to biomechanical and ergonomic aspects of sitting and the social and cultural connotations of chairs and seated posture. However, as related elements in the classroom environment, tables and desks were incorporated into the inquiry where deemed appropriate. Findings from iterations of field research were used to develop and test a design concept and to propose design guidelines for school chairs with greater relevance for those in primary education.

1.3 Personal motivation and research perspective
As a furniture designer, with a background in the office furniture industry, an apparent lack of design input in educational furniture presents me with a professional challenge to explore. Having body conscious knowledge through experience of teaching and practicing yoga has reinforced a personal philosophy that the needs of individual users should be the driving force in designing products.

Practicing and teaching yoga also influenced my views on sitting and resulted in me questioning the design of chairs and currently accepted ways of supporting seated postures. Reflection, many years later, on my undergraduate design for a dining chair caused me to reconsider my process. I had designed a chair that in essence replicated an existing design precedent but with a different aesthetic appeal. I have had time to reflect on its design credibility and I realised that a closer observation of dining as an activity would have led to something innovative and altogether more interesting if not more useful.

This emergent understanding formed the basis of my design practice for an MA research project that resulted in a primary school chair that moves with the person using it. The study focused exclusively on a small number
of end users and the product was licensed to a manufacturer in the education market for four years until January 2015.

This product represented a small step towards more user-centred school furniture design and the fact that it was sold into schools represented a partially successful outcome. However the fact that the product was developed and produced in one size probably limited its market appeal. More importantly, the commoditisation of school furniture further limits the appeal of a product designed exclusively with benefits in mind for the end user. There is room for research to establish understanding of the field, mapping the territory to establish viable routes to facilitate a change.

Last, and by no means least, being slightly smaller than average in stature I have spent a lifetime shifting uncomfortably on seats in various educational institutions, on public transport, in theatres, cinemas and other places and so I have a personal interest in making public seating more comfortable for all.

1.4 Theoretical location of the research
The research project sits at an intersection between ergonomic theories and educational practices, as observed in a primary school. In this research project human-centred design (HCD) practice is the central activity that connects each realm (Figure 1.01).

![Figure 1.01 Model representing the theoretical location of the research](image-url)
Participants in the HCD process could have been drawn from a broad spectrum of stakeholders who would come into contact with a school chair during its lifespan. For example those involved with its manufacture, marketing, distribution, maintenance or disposal. The research is primarily concerned with children postural welfare in the classroom; as a result pupils and their class teacher have been placed at the core of the study.

As material objects school chairs also sit at an intersection between educational culture and practices, and the commercial worlds of design and manufacturing. As such they are subject to forces from within each; and between the two are children with no voice in what they have to sit on during the school day. The people who buy classroom chairs are not the people that use them. Even when designs are developed and tested with people from the intended user group there is no assurance that they will be chosen by those who procure them (Papanek, 1984, p.112.) Their motivation is different.

In 2014/15 almost £42 million was spent on school furniture in England. This marks an increase of £2.2 million from the previous year (Education Business, n.d.). Market forces, right or wrong in education but crucial in business, have the potential to be the driving forces for decision making in the design, manufacturing, marketing, procurement and, ultimately, use of school chairs. The first priority of all in the supply chain should be to provide appropriate physical support for the pupils.

This research takes a holistic approach and by so doing views the primary school chair, the object of design, in its wider social and cultural setting. It gains insights from this perspective on the extent to which external forces can affect the people who have to use primary school chairs. New knowledge is generated by the research that is pertinent to the design of school chairs and is of significance across design, commercial and educational practices.
1.5 Research question
It is in the pupils’ best interests for those in education and associated commercial enterprises to ensure that primary school chairs are well designed, are comfortable to use and provide appropriate support for children. A problem has been identified with school chairs and it appears to stem from the design. This is an on-going issue, yet the design of the school chair seems to have changed little over time and it is particularly noticeable in comparison to office chairs. Therefore, the precise nature of the problem is unclear. A fundamental part of the human-centred design process is to understand the real nature of the problem (Norman, 2013). This ensures that the resulting designed solutions are appropriate. Therefore, the main question set to guide the research asked:

What will a human-centred design approach reveal that can be used to develop designable features for primary school chairs?

The question was used to establish broad parameters for the theoretical and practical location of the research. A series of secondary questions were also used to guide the selection of specific methods for gathering data. These will be discussed in more detail in relation to the methodology in Chapter 3.

1.6 Practical location of the research
The field research took place in one classroom in a Greater London state primary school during term time. To protect children’s identities the school is not identified by name (Data Protection Act, 1998). However, the most recent Ofsted report, in 2013, described it as being larger than average in size, with pupils aged from 3 to 11 years; the majority of pupils were of White British heritage although a larger-than-average proportion came from a number of different minority ethnic backgrounds; the proportion of pupils who spoke English as an additional language was broadly average as was the proportion of disabled pupils and those with special educational needs.
The school was housed in a three storey Victorian building with high ceilings and large windows offering a great deal of natural light (and a great deal of heat in the height of summer). Some of the classrooms, including the one used during research, had been knocked through to create more room although this created a proportionally long narrow space. Figure 1.07 (on page 10) shows the classroom’s layout in 2013. There was an eclectic mix of old and new furniture throughout the school. Chairs varied in size across year groups. They also varied in their design as illustrated in the examples, Figures 1.02 - 1.05, below. New chairs were a type compliant with the European Standard BS EN 1729 (BSI, 2007, 2015).

![Figure 1.02](image1) ![Figure 1.03](image2) ![Figure 1.04](image3) ![Figure 1.05](image4)

A selection of Key stage 1 chairs
Source: the author, originals in colour

The classroom in which the research was based was on the first floor of the building. The corridor outside was lined on one side with named coat pegs and a parallel year one class occupied the adjacent classroom. To one side of the room large windows overlooked a playground and on the other a semi glazed partition wall allowed passers-by to see in. The space was furnished with recently purchased tables and chairs (similar to the one illustrated in Figure 1.05, storage cupboards, a book corner, a “shop”, two shared computers and a printer. The floor was finished mainly in vinyl tiles with a carpeted area in front of an interactive whiteboard. Below, Figure 1.06 shows a teacher’s eye view of the classroom.

The teacher’s furniture comprised a small computer table, for a laptop, and an office chair. This was situated at one end of the classroom beside the
interactive whiteboard, placing her at the front of the class for most plenary sessions. During morning sessions, which were more formal and when the children were working at tables, the teacher would circulate the room helping individual pupils. In some lessons, such as maths, there might be other adults at tables working with groups of pupils on specific tasks. There was often at least one other adult in the room, either a teaching assistant or a specialist to support a child with particular needs. In two of the three classes observed, in 2013 and 2014, there was one pupil who required additional support and needed a personal workstation with specific design requirements.

Figure 1.06 A teacher eye view of the classroom  
Source: the author, original in colour.
Figure 1.07 Classroom layout in June 2013
Chapter 2: A Contextual and Literature Review

This research began with the premise that the archetypal school chair is problematic and the design has somehow become suspended in time. The project’s aim was to establish what information design-led research will uncover that can be used to improve primary school chair design and bring it up to date as a counterpart to modern teaching practices. Literature and other relevant materials were critically examined to define the theoretical and practical location of the research.

The contextual review is presented in five sections. Firstly, because the primary school chair provides pupils with physical support, the generic ergonomic interplay between seated posture and chair design will be examined. Secondly, more specific ergonomic literature on educational furniture and, where possible, how this relates to school chairs in particular, will be discussed. These two sections will establish different paradigms of sitting alongside other factors for consideration in the design of a school chair. They will also form a basis for evaluating literature and products in subsequent sections and throughout the research.

Thirdly, a presentation will be made of the outcomes of an investigation of social and cultural aspects that have been, and continue to be, generally influential on the design of chairs. A fourth section on historical context will describe the school chair’s design heritage in relation to educational culture, from Victorian to contemporary times. The section will conclude with a discussion on aspects of the current education system and how they affect the school chair’s design, procurement and use today. The final, fifth, section will offer a critical evaluation of alternatives to the archetypal school chair.

Overall this review will examine how and when the evolution of the design of primary school chairs stalled, how the status quo is being perpetuated and it will identify where there is scope for design research to initiate change.
2.1 Ergonomic Aspects of Chairs and Seated Posture

Norris and Wilson (1995) describe ergonomics as the study of people’s interaction with their environment. The intention being to improve these interactions with, for example, tools, products, buildings and information. The purpose of this design research, therefore, is to improve sitter-chair interaction. Examining ergonomic literature in this area will explain factors that need to be taken into account to achieve this. At the same time it will establish a framework that can be used to discuss and evaluate the design of chairs. Later, examination will be made of ergonomic literature that is more specifically related to school pupil-chair interaction.

As a utility object a chair should:

“…provide stable bodily support that is: comfortable over a period of time… [and] appropriate to the task or activity in question” (Pheasant and Haslegrave, 2006, p.121).

This definition, of the functional requirements of a chair, can be used to establish a set of criteria for consideration in designing a chair. There is a need to understand how a seated person perceives comfort, how the chair relates to different physical attributes of the human body, and how the body can be supported, all in relation to time and activity.

Perception of comfort

The concept of comfort is complex and subjective (de Looze et al, 2003). This makes it difficult to measure the comfort of one chair design that is intended for a wide range of users. However, comparing the feeling of comfort with the opposite sensation of discomfort can provide a basis for its evaluation. Zhang et al (1996) report that the perception of seated comfort can be associated with general feelings of “relaxation and well-being” (p.6) and that users finding the chair aesthetically pleasing may increase these good feelings. Whereas the perception of discomfort is described as experiencing actual physical discomfort that is due to an inadequate biomechanical fit between the sitter and the seat. This study suggests that in order to design a comfortable chair, taking a holistic
approach to understanding the end user experience is vital; one that takes account of their affective experience of the product as well as the level of physical support it affords.

Furthermore, Helander (2003) argues that aesthetic features such as lavish upholstery are easier for people to perceive than the ergonomic features that improve the sitter-seat biomechanical fit. Both of the studies above imply that to ensure a chair design is comfortable the designer needs to have two things: one, an appreciation of the chair’s proposed end user’s (or representatives of that user group) experience of using a product and two, an ability to apply relevant biomechanical knowledge to the design. The studies may also suggest that instead of pursuing the design of a comfortable chair, the ultimate aim could be to design one that is simply not uncomfortable, thereby being one that is unobtrusive to use.

Pheasant and Haslegrave, (2006, p.121) indicate a triangular relationship between many, variable characteristics of the person sitting, of the seat they are using and of the task in which they are engaged. The designer needs to consider how traits of all three can affect the comfortable use of a chair or alternatively, can minimise the sitter’s discomfort.

To summarise, comfort is a subjective experience affected by many complex variables. In designing a chair the user, the chair, and the task are all part of the same dynamic and should not be considered in isolation, denoting a holistic approach. A comfortable seat may be one that is unobtrusive to sit on over time. Therefore, aiming to design a chair that a sitter does not describe as uncomfortable to use, over time, is perhaps a more realistic design ambition than attempting to design one that is viewed as comfortable to use by many different people.
Comfort and chair features

“Chair n. 1 a separate seat for one person, with a back and four legs…” (OED, 2012).

The definition above describes a chair design with basic features comprising a seat, backrest and four legs. However, chair features could also include armrests, headrests, footrests and upholstery. These features are functional but they are open to interpretation by designers, depending on the requirements of the final finished piece. As discussed previously the requirements should begin with the characteristics of the end user and how they can be supported.

In seated postures the pelvis should distribute upper body weight down (Calais-Germaine, 2007, p.40; Pynt et al 2001; Bridger 2009) through protuberances at the base known as the ischial tuberosities, (Akerblöm, 1948, p.181; Mandal 1985; Pheasant and Haslegrave, 2006, p.124). Some weight also passes through the feet (Parcells et al, 1999). Therefore, the minimum design requirement to support a seated person is a physical means of supporting his or her ischial tuberosities, the person’s legs forming a tripod effect transferring weight down through the feet.

In adults the ischial tuberosities can support up to 75% of seated body weight (Parcells et al 1999). This puts a considerable amount of pressure in a concentrated area so is likely to be uncomfortable to maintain for any length of time. The sitter’s thighs being supported by the surface of a seat could redistribute some of this weight. However, thighbones are the heaviest human bones (Calais-Germaine, 2007, p.180), and soft tissue can become compressed between these bones and the seat surface and, over time, this also causes discomfort (Akerblöm, 1948, p.157; BSI, 2015, p.60). Applying padded upholstery to the seat is one solution but its effect can be negated if the upholstery lacks sufficient density. If the body sinks too deeply into the upholstery the soft tissue can become sandwiched between the thighbones and the underlying seat structure. As discussed
Previously the matter of upholstered chairs is complicated because people’s perception of comfort is often associated with their initial aesthetic appraisal. In some circumstances plush upholstery may be ideal but its presence should not compromise the postural requirements of the sitter.

Assuming a physical posture depends on the correct positioning of the body’s centre of gravity. Maintaining a pose relies on reflexes constantly adjusting ligaments and muscles (Bridger 1991). These can be described as micro movements, held for a short time; macro-movements are the larger postural adjustments between one posture and another. (Vergara and Page, 2002) Both are important, micro movements to maintain a steady posture and macro movements alleviate discomfort by redistributing body weight.

Biomechanics of the spine, relative to seated posture, will be discussed in more detail later. However, it is notable that studies by Wilke et al (2001) provide evidence that different seated postures affect physical comfort (or discomfort) by altering the amount of pressure in the intervertebral discs. For example the research shows that leaning forwards when sitting generates a greater disc pressure than an upright, unsupported position. However supporting the arms, on the thighs for example, decreases spinal pressure and using the support of a chair’s backrest creates a greater reduction. Overall, a “slouched”\(^2\) posture causes the least pressure (p.S117). By contrast, sitting bolt upright, as historically expected of well-behaved school children, generates even greater pressure than relaxed standing. Therefore, when people are sitting macro movements to change posture and use of the support of designable features like backrests and armrests could ease discomfort by reducing spinal disc pressure and re-distributing body weight. Åkerblom, (1948, p.12) refers to different seated postures as resting ones and maintains that a well-designed chair should “permit adoption of different resting positions” (p.168). On this note a key

\(^2\) Slouched sitting – the subject has slid forwards in the seat so that the upper back is leaning against the backrest but the lumbar portion is not.
consideration for designers, offered by Cullis (2010) is that designable chair features such as, for example, seat and back configuration, may imply that there is only one way to sit (p.201).

In summary, movement does not only help to maintain a posture but is also a means of alleviating discomfort. Different chair features like backrests and armrests can be used to minimise discomfort. A good chair design would support a variety of different postures to minimise spinal disc pressures and would maximise the opportunity to redistribute weight. In relation to chair design, although physical comfort remains subjective for the seated person, the designer can employ different designable features to provide a means of alleviating discomfort. This configuration of features could also affect the way in which a chair is used.

Anthropometry
The human race comprises a vast range of shapes and sizes, with as much as 40cm global variation between the tallest and shortest people (Norris and Wilson, 1995, p.8). Anthropometric data consists of human measurements recorded for use in designing products, tools and working environments (Chaffin et al, 2006, p.37). It is ergonomic information applied to a design so that people can use products with comfort and safety by ensuring a good fit between a user and a product (Norris and Wilson, 1995, p.2). The use of this objective information in design stems from data, collected during World War II, becoming available to the public in books such as *Measure of Man*, by Dreyfuss, and *Humanscale* by Diffrient (Olivares, 2011, p.21).

Generally accepted principles of chair design are that dimensional details, for example, of the seat height, depth and breadth should be determined by consulting the intended user group’s anthropometric data (Pheasant, 1987, p.142). The data is acquired by measuring the target population using standard postures and equipment and more recently body scanning technology. An accepted principle of applying anthropometric data to
chair design is that the ideal seat height is determined by the intended user’s popliteal height\(^3\). However, the danger of using this means of calculation is that it makes an assumption about how people actually sit. This point will be discussed in more detail and in relation to different seated postures below.

Relying solely on the application of anthropometric data to a designed object as a means of ensuring user compatibility has its limitations. A number of factors can influence the physical dimensions of human beings - including age, gender and ethnicity (Kroemer and Grandjean, 1997 p.35) - so the source of the data needs to be appropriate. Also, the measurements are based on a sample of target population, so data accuracy depends on the size of that sample and the nature of the target group (Norris and Wilson, 1995, p.4). Precise measurements of complex skeletal structures such as lumbar curvature can be difficult to establish because external appearances of individual people can be affected by muscle tissue varying between individuals (Calais-Germaine, 2007, p.31). Also the same body part can be measured in different ways making it important to establish what criteria were used during measuring before applying them in the design process.

Furthermore, anthropometric data is represented in different ways. Static anthropometry measures attributes like stature, weight, body breadths, depths, circumferences, seated dimensions, face, hand, and foot dimensions. (Norris and Wilson, 1995, p.3) Dynamic or functional anthropometry measures the “limits of movement” such as the maximum height a person can reach up to. However, it does not reveal the different ways people find of attaining that limit e.g. people might stretch, jump or twist in order to reach something (Norris and Wilson 1995, p.3: Norris and Smith 2008, p.40).

\(^3\) Popliteal height is the length of a person’s lower leg measured when seated, from the floor to the underside of the back of the knee.
Anthropometric data can be presented in percentile tables (standard statistical distribution) providing a means of selecting a more precise target within a given group. Using stature as an example, an average person in a given population would be in the 50th percentile. On either side of this point 50% of the population would be taller and 50% would be smaller (Pheasant and Haslegrave, 2006, p.18).

Guidelines suggest that school furniture should be designed to accommodate users between the 5th and 95th percentiles (Norris and Smith, 2008, p.50). In practice this excludes 10% of the user population (Kroemer and Grandjean 1997, p.33). However, it is possible to capture more of the target population with a product design, as office furniture manufacturer Herman Miller demonstrates by manufacturing three different sizes of the Aeron chair in order to accommodate 100% of anthropometric variables (Herman Miller, 2009). It is then up to the purchaser to select the appropriate sizes for the end-users.

To recap, anthropometric data provides designers with useful dimensional references to ensure a good physical fit and, by extension, a degree of comfort and safety between a product and its intended user. Due to variations in data collection procedures and in reporting, this information should not be taken at face value. Anthropometric data can be applied to the design of a product to ensure it will physically fit certain, and usually limited, percentages of a given population. However, since it does not reveal how people actually use products it should not be relied upon as the sole source of data.

**Seated Postures**
There are three ergonomic schools of thought on seated posture that could influence the design of a chair. These paradigms, described below, can also provide a means of evaluating the design of a chair. First, because a great deal of ergonomic research into seated postures is based on the effects on the spine of sitting and on the possible causes of back
pain, it is worth understanding the biomechanics of the human vertebral column.

*The spine*

The human spine consists of 24 bones, or vertebra, which are separated by deformable discs, making it a flexible structure (Pheasant and Haslegrave, 2006, p.123). Viewed from the side, when standing, the spine forms four natural curves (see Figure 2.1). Two are concave, at the cervical (neck) and lumbar regions (immediately above pelvis) whilst the thoracic or dorsal area (where the ribs attach) is convex. The lowest five vertebrae are fused and attach to the pelvis forming the sacrum.

Individual vertebrae are kept apart by discs of cartilage; these also act as shock absorbers (Calais-Germaine, 2007; Bridger, 2009). The discs are a combination of fibrous material and gel like fluid retained within a flexible wall (Chaffin et al, 2006, p.32). Movement is beneficial to the health of the spine as it causes vertebral joints to expand and contract resulting in the discs between being squeezed and released (McMillan et al, 1996). This action feeds the discs, which have no blood supply; as disc pressure increases some fluid is expelled and as it decreases fluid is reabsorbed (McMillan et al, 1996; Chaffin et al, 2006, p.32). Conversely, holding a static posture that causes the spine to be flexed for too long can cause discomfort and may also cause long-term damage to the discs. (Kingma et al, 2000).

In short the spine is a mobile structure that is reliant on movement for its wellbeing, whilst lack of movement could be detrimental and cause discomfort. Different ways of sitting affect the spine and other body parts in differing ways.
Right angle sitting
The conventionally accepted Western seated posture is in favour of the sitter’s hips and knees forming a 90° degree angle⁴ (Mandal, 1984; Bridger, 1991; Cranz, 2000; Opsvik, 2009). This can be referred to as right angle sitting (BSI, 2007, p.28) and has a particular impact on lumbar curvature and intervertebral disc pressure (Keegan, 1953) that can cause lower back pain and longer term back problems. As the body moves from standing to sitting on a chair the hamstring muscles, located behind the thighs, pull at the base of the pelvis causing it to rotate. In turn, this changes the lumbar curve from concave to straight or even convex (see figure 2.02) and consequently squeezes and deforms the intervertebral discs. Remaining seated like this for any length of time could be uncomfortable in the short term and bad for the sitter’s back in the long term.

⁴ Molenbroek et al, (2003) indicates that the lower leg can extend up to 30° beyond vertical without compromising comfort (p.688).
Open angle sitting

Among physiotherapists there is a lack of consensus on what constitutes an optimal seated posture for the spine. However, the ability to retain a degree of curvature in the lower back appears to be a desirable attribute (O’Sullivan et al, 2012). For example, it has been known for some considerable time that a seated posture replicating a natural lumbar curvature places the least amount of pressure on spinal discs (Keegan, 1953). This is also known as open angle sitting (BSI, 2007, p.28) and is associated with chairs with a higher seat position than would be used for right angle sitting. Keegan’s (1953) study on seated posture and lumbar curvature identified a neutral or normal lumbar position, with an optimal 135° degree trunk-thigh relationship. This pose also allows “balanced muscle relaxation” (Keegan, 1953, p.592). Muscles working in opposing pairs, on the back and front of the body, to keep the body upright will be exerting a similar amount of effort. This indicates that an additional benefit of sitting this way is that supporting muscles should not tire so quickly and so the posture should be more comfortable to maintain. Keegan’s study also recommends that in order to preserve lumbar curvature the design of

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[^5]: In the literature there are differing specifications for the exact angle but in general terms open angle sitting relates to thigh-torso angle far greater than 90° degrees. For example the British Standard for school furniture (BSI, 2006, p28) stipulates a torso to thigh relationship of around 120° degrees as an open angle seated posture.
a chair’s backrest should be contoured to provide a lumbar support and space below, in order to accommodate the protruding sacrum.

Following Keegan’s recommendations, maintaining a neutral lumbar curve has had lasting implications for the design of Western seating (Noro et al, 2006). The Western approach has been to push the spine into a neutral position by shaping the chair’s backrest. Yet spinal curvature varies between individuals (Calais-Germaine, 2007, p.31) so the backrest shape may not fit the lumbar curve of all the intended sitters. By way of contrast Eastern cultures have cultivated different ways of sitting. For example, a Zazen posture, typically assumed by a Zen priest during meditation, involves sitting on a firm cushion, or zafu, on the floor which raises the pelvis and, in doing so, places the knees below the hips (Noro et al, 2012) in effect creating an open angle seated posture.

Figures 2.03 and 2.04 illustrate this concept by showing the difference between sitting on a floor without support and sitting on a Zazen style Zafu cushion. Note that when unsupported the sitter’s knee is raised above hip level and their lower back is flatter. When supported by the cushion the sitter’s knee is lower than their hip and a curve is visible in the lumbar region. An open angle style of sitting does not therefore require a backrest to shape the lumbar spine as it allows the sitters to establish their own natural lumbar curve. Giedion (2013) observed that the Eastern or
“Oriental” way of sitting was a means of the human body finding “relaxation and comfort within itself” (p.260) rather than the body taking on the external form of the chair. In this realm of sitting a well-designed chair should provide a platform for “upwards” support rather than “deforming” the body by letting it sink (Cranz, 2000, p.129).

**Dynamic sitting**

An open angle paradigm of sitting appears to be more sensitive to the anatomical needs of the seated person than the right angle style. This makes it worth exploring further in the design of chairs. However, there are limitations to its exclusive use. This view relies on assessing the trunk-thigh relationship and its effect on the lumbar spine but it overlooks the spine’s other naturally occurring curves that could also be affected by sitting. Although lower back pain is commonly associated with seated postures, discomfort in the neck area and dorsal region are also experienced (Vergara and Page, 2002). Furthermore, the fact that physiotherapists cannot agree on what a good-seated posture looks like, other than having a degree of lumbar curvature (O’Sullivan et al, 2012), is an indication that a single best posture does not exist.

Research on seated posture and spinal comfort in the realm of open angle sitting considers spinal movement in one plane (viewed from the side). Yet the human body is capable of complex three-dimensional movements. In anatomical terms human bodies can flex, extend, abduct, adduct and rotate (Blakey, 1992, p.5). The trunk alone can move through three different planes (Calais-Germain, 2007). Therefore, the third school of thought deals with dynamic sitting (Breithecker, 2005) and, as the name suggests, takes into account the human body’s ability to move in multiple directions and the associated health and comfort benefits of movement. This does not necessarily mean that the sitter should be in constant motion but that chair design should accommodate micro and macro movements, discussed previously, which are used to remain balanced and to minimise discomfort. As seated discomfort has been shown to increase
over time (Zhang et al 1996) *dynamic sitting* arguably presents the most human-centric paradigm within which to locate the design of chairs.

To summarise: *right angle* sitting is conventionally accepted but is not a natural posture for a person to assume because of the effect on the lumbar spine. The conventional way to overcome this is to use a chair’s backrest to shape the spine. Creating the *open angle* posture by raising the sitter higher and allowing the spine to assume its natural curvature is more sympathetic to human biomechanics and is likely to be more comfortable over time. It is worth investigating further how this can be incorporated into chair design; however, it does not, take into account that the spine can move in many directions and the associated health benefits of movement. Therefore the realm of *dynamic sitting* can be considered as a more effective way to take account of the human body’s ability to move and the ways that people use chairs to remain comfortable over time.

**Summary of key points**

This section has considered ergonomic aspects of seated posture and how these can affect the design of chairs and how they can be used in the evaluation of chair designs. Four areas were discussed: 1) the perception of comfort, 2) ways that designable chair features can affect this, 3) the principles behind and limitations of applying anthropometric data in design, 4) a critical evaluation of three paradigms of seated posture.

The highly subjective nature of comfort makes it challenging to design a comfortable chair to suit many different people. However, the literature indicates that the triangular relationship between the sitter, their chair and the task are all implicated in affecting perceptions of comfort, requiring an appreciation of the chair in context. Furthermore, the intended end-user’s (or representatives of the target population) opinions need to be sought and accounted for but not at the expense of the application of biomechanical know-how. This indicates the need for a collaborative
design approach where each party, designer and user-representative can bring his or her expertise to the project.

Chair features such as seats, backrests and armrests perform various functions; they signify how a chair should be used and can help alleviate discomfort by distributing weight and accommodating postural alterations. Postural movement is good for spinal health and can help to maintain comfort over time. The presence of upholstery can be considered as a comfortable feature by the sitter but, depending on the density, may actually contribute to physical discomfort. Therefore, the application of upholstery to a chair needs to be assessed along with the level of biomechanical support that is required.

Anthropometric data can be used to determine a good physical fit between a sitter and their seat but it has limitations and so needs to be applied with care. For example, this type of data does not take into account how people move, which reduces its exclusive application to within either right angle or open angle sitting paradigms. Furthermore, it is troublesome that 10% of the user population might be overlooked as these people are at the extreme ends of the percentile scale and so are likely to be those most affected by a poor physical fit.

Different ergonomic schools of thought on seated posture can affect the design and use of chairs. Evidence indicates that a right angle seated posture is likely to be uncomfortable to hold for long and also potentially detrimental to long-term spinal health. Adopting an open angle sitting position can achieve more natural lumbar curvature and this is preferable, but reliance on this aspect alone overlooks a person’s ability and healthy inclination to move. By comparison, the realm of dynamic sitting offers a means of developing and evaluating chair designs around people’s natural tendency to move.

Design within the dynamic sitting realm requires an understanding of how a person would use such a chair and this requires different types of data to
be collected. A prudent designer therefore needs to consider information from many different sources and to understand all the implications of its application. This would include understanding the nature of any associated tasks that the sitter may be engaged in.

2.2 Ergonomics Aspects of School Furniture

The previous section reviewed literature to reveal, from a general perspective, ergonomic aspects that need to be considered in the design of a chair to improve sitter-chair interaction. The overall aim of the research project is to improve the primary school pupil-chair interaction. As a result, this section will deal more specifically with literature on the ergonomics of school chairs. Although the research centres on the primary school chair literature pertinent to school furniture generally is included, as is literature on secondary school chairs.

Pheasant and Haslegrave’s (2006) earlier statement of functional chair requirements is equally applicable to school chairs in that they should also: “… provide stable bodily support that is: comfortable over a period of time… [and] appropriate to the task or activity in question.” (p.121).

Ergonomic literature reveals why a school chair may fail to meet some of these requirements. Cranz (1998, p.62), citing French orthopaedic physician Dr. Nicholas Andry de Bois, suggests that as early as 1743 the school furniture of the day was causing physical deformities in children. More than two and a half centuries later studies of contemporary school furniture demonstrate a consistent mismatch in physical fit between the furniture provision and the pupils using it (Mandal, 1984; Parcells et al, 1999, p265; Bond et al, 2002; Gouvali & Boudolos, 2006 Saarni et al 2007b; Brewer et al, 2009). As an ergonomic issue these studies demonstrate two things. Firstly, an on-going issue with providing furniture that fits school all pupils; secondly, the likelihood that poor fitting school chairs will be comfortable to use over a period of time and so fail to meet an important functional requirement.
These points are explored further, below, in relation to the three paradigms of seated postures introduced in section 2.1. Two new schools of thought on posture in schools, with pedagogical implications, are also introduced. This is followed by a discussion on designing chairs for children including aspects of balance and sensory development.

Seated postures
Knight and Noyes (1999) define the functional requirements of a school chair as “to support the child when attending to the teacher, and when writing or drawing on the worksurface” (p.748). They note that these tasks require quite different seated postures and that, in terms of providing support, the traditional design of UK school chairs represents a compromise between the two. This observation is reminiscent of Dewey’s comments on chairs that support listening but not doing. This is not its only problem.

Right angle
Conventional school furniture, designed to support right angle postures, has also been shown to be size deficient in different ways; successive generations of children are taller and furniture has become smaller (Mandal, 1984), through desks being too high and chairs too low (Saarni et al, 2007a), or chairs and desks both being too high (Gouvali and Boublos, 2006). An American study found that fewer than 20% of children had an appropriate desk-chair combination to fit their particular size (Parcells, 1999). If this is applicable to an English primary school then 24 pupils in a class of 30 are likely to be using the wrong size of furniture. Simply put, school furniture is not keeping up with pupils’ needs (Gardner and Caglar, 2007).

Having to sit and work in badly fitting furniture has implications for school pupils’ musculoskeletal systems and causes discomfort. Back pain in particular is not uncommon among them. School furniture use has been associated with upper back, lower back and neck pain (Murphy et al, 2004; 2007). Taller students reported more back pain (Milanese and
Grimmer 2004), and particularly neck pain because they had to flex their necks to get close enough to see their work (Murphy et al, 2004). Mohd-Azuan et al (2010) found neck pain most prevalent among primary school pupils studied, followed by upper and lower back pain. However, pupils’ expressing discomfort is not always consistent with using poorly fitting furniture (Brewer et al, 2009) as this can be influenced by children’s perceived satisfaction with the products (Mohd-Azuan et al 2010). The subjective nature of comfort is again apparent, as is the importance of including end-user views, in design development. However, the design of school furniture can only be attributed to pupils’ back pain in part (Linton et al, 1994), as other factors are also implicated, for example, carrying heavy school bags (Murphy et al 2007; Mohd Azuan et al, 2010).

Studies show, how children use furniture features to make postural adaptations; for example, they lean their arms on their desks and use the support of the chair’s backrest to reduce the load on their spines (Geldhof et al, 2007). The large number of negative responses provoked through pupils being required to use a desk-seat combination that did not have a backrest indicates that this is seen as an important feature by school children (Woolner et al 2007b). Likewise, pupils sometimes wrap their legs around chair legs to assist balance (Burt and Benbow, 2008). When engaged in desk based work children have been observed flexing their bodies in order to get close enough to see their work (Mandal, 1984; Murphy, 2004). Yet, when working on paper, pupils adopt more varied postures than when using computer technology (Straker et al, 2009). Children have a similar risk as adults of developing the musculoskeletal problems associated with using computer technologies (Grieg et al 2005).

A one size fits all policy for allocating furniture does not accommodate an entire age group (Gouvali and Boublos, 2006) but formulating an effective system to ensure that all pupils have appropriate products available to them is complicated. Milanese and Grimmer (2004) recommend that school furniture should be designed to fit the 50th percentile of the user population. As discussed in section 2.1, designing for the average user
effectively ignores the needs of the wider user group and, in the case of school chairs, those who would be most affected by a poor fit. Another option would be for adjustable furniture to be supplied (Parcells et al, 1999; Panagiotopoulou et al, 2004; BSI, 2007). However, this type of furniture needs to be adjusted correctly to fit the individual, which means that children would need to be taught how to adjust furniture to fit their own requirements (BSI, 2007, p.34). Yet, when adjustable furniture is present in a school it is seldom found to be set at the correct position for the user (Saarni et al, 2007a). Moreover, proposed size parameters for adjustable furniture have been calculated to accommodate 90% of pupils (Oyewole et al, 2010). This would require the smallest and the tallest pupils having to adjust themselves to fit the furniture.

Other proposed methods are that schools provide a variety of furniture sizes in each classroom (Parcells et al 1999; Gouvali and Boublos, 2006) or, alternatively, measure the popliteal height of children twice a year to ensure the correct chair height is in use (Molenbroek et al, 2003). Both methods would rely on there being correct quantities of different furniture sizes available in the school at any one time and would result in a potential administrative and storage problem.

Children’s growth patterns change with age. Young children tend to grow more rapidly in limb length whereas teenagers grow more in the trunk (Bass et al, 1999). This makes the height and depth dimensions of seats important (Hedge and Lueder, 2008, p.725) in (conventional) primary school chairs. As with all children’s anthropometric measurements, the distance between the back of the knee and the floor varies greatly even within similar age groups (Kroemer, 2006). This dimension is important for determining the correct height for a conventional type of seat; too low and the legs need to be stretched forward or tucked back; too high and feet will not reach the floor, putting too much weight on the thigh and interfering with blood circulation (Knight and Noyes, 1999, BSI, 2015).
A difference of opinion in how anthropometric data should be applied to school chairs is evident between Molenbroek at al (2003) and Mandal (1984). This relates to the chair design and the intended users' anticipated seated posture. Molenbroek et al (2003) used an “anthropometric design process” (p.682) to develop criteria for selecting dimensions for school furniture design. A table denoting user dimensions and the corresponding furniture features are set out (Figure 2.05).

<table>
<thead>
<tr>
<th>User-dimension (figure 4)</th>
<th>Product dimension (figure 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair: 1: Popliteal height</td>
<td>h5: seat height</td>
</tr>
<tr>
<td>2: Lumbar – popliteal depth</td>
<td>t4: seat depth to back support</td>
</tr>
<tr>
<td>3: Waist height while sitting</td>
<td>y: height frontal point back support</td>
</tr>
<tr>
<td>4: Buttock clearance</td>
<td>h6: height lowest point back support</td>
</tr>
<tr>
<td>5: Height lowest point scapula</td>
<td>h7: height highest point back support</td>
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<tr>
<td>6: Hip width, sitting</td>
<td>b3: seat width</td>
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<tr>
<td>Table: 7: Thigh clearance sitting</td>
<td>h2: vertical span below table</td>
</tr>
<tr>
<td>8-9: Buttock – kneedistance minus breast depth</td>
<td>h: horizontal knee space</td>
</tr>
<tr>
<td>10: Buttock–feet depth</td>
<td>h3: horizontal clearance below the table</td>
</tr>
<tr>
<td>11: Elbow height sitting</td>
<td>h1: table height</td>
</tr>
</tbody>
</table>

![Figure 2.05 Application of anthropometric data to school furniture design](image)

Source: Molenbroek et al (2003, p.685)

Popliteal\(^6\) height was found to be the best dimension to use for determining the correct height of a seat; previously stature had been the basis for this calculation. Despite there being an allowance made for the lower leg to extend by up to 30° (p.688) as the accompanying image illustrates (Figure 2.05) this study, and by implication the resulting

\[^6\] Popliteal height - the distance between the floor and the back of the knee when seated, used to calculate a conventional seat height.
recommendations, clearly stem from a right angle concept of sitting. Therefore, a person using a chair that was designed solely on this basis could experience the lumbar postural discomfort, described above in section 2.1, associated with right angle sitting.

In addressing open angle sitting, and as an alternative to using popliteal height, Mandal (1984) proposes that the correct height of a school seat should be at least a third of the user’s height. Furthermore the front portion of a seat should slope for the sitter to achieve the optimal (open angle) 120° trunk to thigh relationship deemed to be beneficial for the sitters back (Mandal, 1985).

Open angle
In the light of Keegan’s research into posture and neutral lumbar curvature Danish surgeon A.C. Mandal (1985) observed that an open angle sitting style is achieved when a person sits astride a horse. The rider is upright but the thighs slope downwards to create a wide thigh-torso angle.

Mandal also noted that school furniture, compliant with International Organisation for Standardisation (ISO) guidelines, was being progressively reduced in size. This resulted in school children having to adopt awkward postures that were bad for their backs. His research also demonstrated that people prefer to sit higher than a conventional seat would allow (Mandal, 1984) signifying that this may be a more comfortable position to assume.

In the 1980s Mandal’s theories, arising from his research into children’s posture and school furniture, were translated into new designs for the Danish market. Figure 2.06 illustrates the changes in spinal angles

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7 Also the desk should be about half the user’s overall height and slope towards the sitter (Mandal, 1984).
8 A version of the chair “BackUp” is currently marketed by Vanerum – SiS in Denmark, the Netherlands and Belgium (Vanerum – SiS, 2016). A chair designed along similar principles is also produced by Aalborg (Aalborg, 2016a)
between sitting in a right angle position, on the left, and sitting with open angle postures, centre and right. In a study comparing this furniture with other different types the primary age pupils consulted preferred Mandal’s higher seats and desks on all points under consideration (Aagaard-Hansen and Storr-Paulsen, 1995).

Similarly studies comparing different types of furniture found that children preferred higher seats and desks (Troussier, 1999) although this did not correspond to a significant change in reported musculoskeletal symptoms (Troussier, 1999; Saarni et al 2009). However, and perhaps of more significance to primary education, is that forward sloping seats and desks were reported to afford a better writing position for young children, causing less neck flexion and a more open hip-thigh angle (Marschall, 1995).

**Dynamic sitting**

Sitting still for long periods of time in schools has been associated with children experiencing neck and upper back pain. (Murphy et al, 2004) Equally, patterns of movement can be identified as strategies for alleviating the discomfort of sitting on conventional chairs (Mandal, 1985; Knight and Noyes, 1999; Cranz, 1998; Opsvik, 2009). These postural changes appear to correspond with the open angle thigh-torso relationship of Keegan’s (1953) studies. School children have been observed rocking their seat forwards onto two legs, tilting the seat, and assuming an open angle posture (Mandal, 1985). When asked, children reported several ways of responding to seated discomfort (Knight and Noyes, 1999). The
three most commonly reported were 1) rocking forwards or backwards on a chair or, 2) adopting a “slouching” posture\(^9\) or, 3) sitting sideways. Less frequently sitting on a leg or standing up were also reported (p.755).

Although these actions could be described as natural and practical responses to discomfort, teachers can misconstrue them as misbehaviour (Cullis, 2010, p.202). This introduces a socio-pedagogical aspect for consideration in the design of school chairs. Knight and Noyes (1999) add another functional requirement of the school chair that being a means of crowd control to “facilitate monitoring of their behaviour and performance and to minimize distracting interactions” (p.748). The biomechanical and affective needs that pupils have of school chairs are just part of the design problem to be addressed. That the chairs are used within the teacher’s domain of the classroom raises other important factors for consideration. There is an apparent tension between the children’s biomechanical needs and the teacher’s requirements. Margolis (2007) observes that although the main purpose of education is widely portrayed as “... training the mind…” schools are equally or, possibly more, concerned with training the body (p.11) observing:

“As elements of what is sometimes termed the ‘hidden curriculum’ children are expected to learn to sit still for long periods of time, to control their bodily functions, wear certain styles of clothes…” (Margolis, 2007, p.11).

Cullis (2010) presents the design of a school chair as “deliberatively prescriptive” (p.202) in that its designable features denote how it is to be sat on, including the degree of pupil movement it facilitates or otherwise. That pupils spend a great deal of time in static postures has been attributed to traditional teaching styles (Geldhof et al, 2007) yet movement is good for pupils’ musculoskeletal health (Straker, 2009). Noting associations in Western pedagogy between sitting still in schools and good behaviour, Breithecker (2006) asserts that, far from misbehaving,

\(^9\) Being slouched is described as: “legs straight out front with shoulder or upper back supported by the top of the chair back and their bottom near to the front edge of the seat” (Knight and Noyes, 1999, p.755).
children who are moving, fidgeting or rocking on their chairs are keeping alert and awake and it also helps their concentration. These types of behaviours should be encouraged in schools, not restricted, by product designs.

Dr. Dieter Breithecker is CEO of the German Federal Group for Posture and Movement Promotion (BAG\textsuperscript{10}). A not-for-profit organisation, BAG researches environmental designs to promote movement. Educational research, undertaken by the group, is based on the principle that the whole child is present in school, not just their head or mind, and that the design of the school environment, including the furniture, should reflect this holistic view. Moving beyond \textit{dynamic sitting} Breithecker and Mahli (n.d.) assert \textit{3D sitting} to facilitate natural, spontaneous and complex micro and macro movements. This requires a chair that does not impede but activates natural three-dimensional pelvic movements. Calling for the application of “\textit{movement ergonomics}” in the classroom for the benefit of pupils’ health and learning (Breithecker, 2005, p11/11) this research field incorporates \textit{dynamic sitting} and explores the potential for dynamic classroom spaces, or “\textit{moving classrooms}”. Such an expansive approach is not confined to an ergonomics enquiry but also needs to include an understanding of pedagogical requirements.

\textit{Moving classroom}

Studies investigating aspects of \textit{moving classrooms} have included a 360-degree classroom in a UK school and a longer term moving school study in Germany and Flanders.

The UK study reported by (Woolner et al 2007a) designed and tested a classroom layout as a distinct move away from the more traditional. The 360-degree classroom, as its name suggests, permits a teacher to teach from anywhere in the room using technology and furniture that can support this. This was an ambitious study to set up but was not successful as a

\textsuperscript{10} BAG - der Bundesarbeitsgemeinschaft für Haltungs- und Bewegungsförderung (BAG, n.d.)
research methodology. The methodological issues will be discussed in more detail in Chapter 3. However, the furniture used in the 360-degree classroom was Qpod\textsuperscript{11}, a seat-table combination. In the evaluation process pupils raised important furniture design issues. The mechanism to adjust the seat heights was problematic and, more significantly, the seats were judged to be dangerous; pupils slid off them. Lack of comfort was a big issue and associated with the absence of a backrest (Woolner, 2007a). These issues became apparent during the trial, which underlines the importance of testing products with an intended user group in the development stages in order to understand the product’s performance from their perspective.

Cardon et al (2004) also reported on a moving classroom in an investigation that compared the postures of children attending a (German) moving school to those in a traditional (Belgian) school. The moving school classroom was configured to ensure that children could choose where to work and so would be able to adopt various different postures. This was achieved by providing furniture that could support different positions or dynamic sitting: including tables with sloping work surfaces together with standing workstations and by creating space on the floor where children could also choose to work. The report found that in the traditional school pupils spent a far greater percentage of lesson time (97\%) sitting statically and in flexed positions, whilst in the moving school they sat dynamically (for 53\% of the time), and were also observed to be standing (31\%) and walking around (10\%). Contrary to expectations freedom of movement in the classroom does not appear to affect the amount of time pupils spend on their work (Cardon et al, 2004).

The BAG perspective on school environments is that a school is a child’s workplace and should be subject to similar ergonomic requirements as an adult’s workplace. Furthermore that being able to change postures and move freely has positive impact on children’s physical health and

\textsuperscript{11} Qpod, as manufactured by Stage Systems was discontinued. A similar design is now produced by Aalborg (Aalborg, 2016b).
educational welfare. Furniture items such as tables and chairs are regarded as educational tools (Breithecker, 2015). In the light of research into task furniture for schools the table and chair combination needs to be challenged and movement should be incorporated into the school day (Milton et al, 2013). The addition of standing workstations has been shown to decrease sedentary behaviour in primary school age children (Hinckson et al, 2013) and could make a positive contribution to learning (Mehta et al, 2015). There is clearly scope for the development of new designs for the education market.

Designing chairs for children
Throughout childhood individuals change and develop physically and psychologically and there are wide differences within the same age groups (Norris and Smith, 2008, p.41). Designing products for children requires an understanding of what these changes are and how they may affect the use of a new product or vice versa. For instance, Keegan’s (1953) research into seated posture and lumbar pain led to chair backrests being shaped to push the sitters spine into shape. Yet Calais-Germaine (2007) indicates that spinal curvature is highly individual: therefore a shaped backrest may not be appropriate. In studies evaluating school chairs, children have commented that shaped backrests are not comfortable (Knight and Noyes, 1999). On this matter it is particularly notable that a child’s lumbar curve may not form until puberty (Lueder and Rice, 2008, p.195) this suggests that children may need a different kind of seated support to adults. Moreover, as children are “... developing postural habits that should help protect them when they are adults” (Lueder and Rice, 2008, p.190), it is most important that good postural habits are recognised and supported by any furniture that they might have to use. Karvonen et al (1962) suggest that pupils ought to be given training in good-seated posture and there is an indication that this may be helpful (Dockrell et al, 2010) although it has also been found that children with several years of postural training were still observed sitting awkwardly in order to get close enough to their work to see it (Mandal, 1984).
Lueder and Rice (2008, p190) caution that products like school chairs should encourage movement but that the postures adopted should not be physically extreme. Likewise, Murphy et al (2007) advise that children may not use furniture as a designer intends and may adopt awkward or static postures causing neck and back discomfort from muscle fatigue.

Balance and sensory development
Bridger (2009) summaries the key ergonomic characteristics of good posture as having a symmetrical body, an upright trunk, requiring minimal muscle activity and having some form of external support. The body uses the force of gravity to remain upright (Cranz 1998, p.128) and maintaining an upright trunk requires complex interactions between the body’s bones, muscles and ligaments. It also involves development of the relevant sensory functions that create and maintain balance. Children use intuitive responses to form and maintain balanced postures. These are “righting reactions” that keep the body upright, “equilibrium reactions” for balance and “core muscle development”, essential for good posture (Lueder and Rice, 2008, p.192). Postural muscle development begins in babyhood and this prepares children, who develop at different rates, for manual tasks (Burt and Benbow, 2008, p.691).

Control over large muscle groups, required for balance and stability, is usually acquired before fine motor muscles are used for manual dexterity (Hunt, 2001). “Postural stability, fine motor control, visual coordination, and cognitive perceptual skills are all required for children to sit and write effectively” (Burt and Benbow, 2008, p.716). Therefore furniture that affords good postural stability could assist children in accomplishing the fine motor skills required in a task such as writing. Conversely, children with poor postural stability and balance often have difficulty at school; for example, some pupils have been known to fall off seats (Burt and Benbow, 2008, p.692). These factors all imply that for the purposes of chair design, children should not be seen as small adults and that products should be developed to suit their particular needs.
Implications for Research
That school furniture does not fit pupils is an enduring ergonomic problem. However, relying on the application of anthropometric data to a basic form is unlikely to produce a chair that will function well or be comfortable for all pupils in one class. Furthermore, correlating popliteal height to seat height is arguably predetermining a right angle seated posture with potentially bad postural implications for the end user. School chairs designed to suit an open angle seated posture could provide a better basis for the design particularly as this has been found to be a good way to support young children when they are writing. However, the additional perceived benefits of dynamic sitting in schools should see this taken up as the basis of school furniture design. Yet, this is not simply an ergonomic problem but one where pedagogical values come into play.

Educational practices within the school system and classrooms can also affect pupils’ postural behaviour and may cause children to be directed to sit in ways that are counterintuitive to spinal health. Therefore as the people directing the children that are using classroom furniture, teachers could offer further insights to inform the research and development.

Children have particular and individual developmental needs that could affect the way they sit and by extension their school work. They are not simply small-scale adults but are developing towards adulthood. At the most basic level children’s chair requirements may appear similar to adult requirements but they also have more specific needs depending on their level of development. This presents a case for designing task specific furniture to suit children’s requirements and to question the practice of scaling down adult furniture for use in schools.

2.3 Social and Cultural Aspects of Chairs and Seated Posture
Ergonomic aspects, discussed above, can be employed to assist in designing a chair to optimise the end user’s experience. By investigating historical developments in the design and manufacture of chairs this
section will explain how social, and cultural values have come to take precedence over end user concerns. Consequently, the design of chairs generally, and school chairs in particular, tend to be caught in the least human-centred paradigm of right angle sitting.

“Chair n. 1 a separate seat for one person, with a back and four legs.” (OED, 2012).

The dictionary definition describes a particular structural form and function. In Western culture chairs are well-known objects:

“...their general form and genre are well established and culturally embedded; we recognize them.” (Naylor and Ball, 2005, p.60).

Kosuth’s conceptual artwork, One and Three Chairs, succeeds because we recognise, without question, the idea of chair in each of the three ways it is presented; in a two dimensional photographic image, a three-dimensional form, and described in a written text (Figure 2.07).

Similarly, the way that we use chairs is ingrained in Western culture (Mandal, 1984; Cranz, 2000) because generally our chair design has evolved around the same, commonly accepted, assumption of a correct way to sit. This 90° or right-angle way of sitting, previously described, as
potentially harmful to the needs of the sitter has been upheld through the late 19th century and much of the 20th century as an indication of social propriety (Cranz, 2000). During the Victorian era, patent chairs were designed that could provide comfortable postural support for different types of seated activities (Giedion, 2013). However, these early ergonomic chairs that tilted or swivelled did not match social values of the time when rigid and upright-seated postures were a physical demonstration of morality (Pynt and Higgs, 2008), which at the time, appears to have been of far greater importance than comfort.

Research suggests that sitting upright is an unnatural pose and cannot be held for a long period of time (Mandal, 1984, 1985). Yet, paradoxically, this manner of sitting has continuing influence on the design of seating and school chairs in particular. This unchallenged standardised view of seated posture proves to be problematic in light of the evidence revealing the biomechanical difficulties and detrimental affects of sitting like this for any length of time, previously discussed in section 2.1.

Advances in manufacturing techniques have also influenced the design and construction of modern chairs. Early European mass manufactured chairs were pioneered in the 1830s by cabinetmaker Michael Thonet. Wilk (1980) relates that Thonet’s earliest wood-bending experiments replaced wooden parts, previously hand carved by craftsmen, with laminated veneers shaped to form the sides and legs of chairs. From the 1850s the Thonet furniture business concentrated on developing a means of bending solid lengths of beech timber that would be less labour intensive than laminating timber parts. By the late 1850s “...Thonet’s production of furniture moved completely out of the realm of craft into industrial production.” (p.23). The company had established a manufacturing process that simplified chair design to a kit of parts that could be transported and assembled at a later stage. This process is exemplified by Thonet’s “No 14” chair (See figure 2.08).
Industrialisation and mass manufacturing not only created new methods of making chairs but also generated a greater need for seats to support an increasingly sedentary workforce (Cranz, 2000) and, following the 1870 Elementary Education Act, vast numbers of children had to be accommodated in schools, also requiring places to sit (Seaborne, 1971). However, at the time the design emphasis was on efficient manufacturing methods, reducing chair designs to kits of parts, at the expense of, or without regard to the needs of the human users. Furthermore, the chair forms that were produced generally corresponded to the right-angle concept of sitting.

Mandal (1984,1985) suggests that illustrations of right-angled sitting in international design standards demonstrate a “world-wide unanimity” (Mandal, 1984, p.48) and so this way of sitting represents an ideal (see figure 2.09), which could explain its longevity.
Mandal (1985) plots the development of chairs, as we know them, from symbols of power and authority ‘a status symbol of the ruling class’ (p.8) through 19th century industrialised mass manufacture to 1930s Functionalism, describing the chairs of the era as “instruments of torture” (p.11). He remarks on a preoccupation in the design of chairs with aesthetic and technical concerns at the physical expense of the end user. Mandal’s view of this failure of modern chairs is shared with Cranz; “We design them; but once built, they shape us.” (2000, p.15)

Architect and Alexander Technique teacher Cranz (2000) claims that modern “designer chairs” are evaluated on elements of their style such as “line, proportion, shape, materials, decoration and craftsmanship” (p.65). These are important considerations in product design but in the case of an object intended to support the human body they should not be at the expense of the end users’ needs. In a critical examination of seating in Western society Cranz investigates the chair’s design heritage and ergonomic credentials and, like Mandal, emphasises how the many variants of design types often fail to relate to the user’s physical attributes.

Achieving an open angle posture is difficult when sitting on a chair designed for right-angled sitting, particularly when carrying out desk-based activities. Information regarding what is good posture and why it is good can also be confusing, as is shown in Figure 2.10. The images illustrate an article on good posture and office seating; each image shows an increasing thigh to torso angle. Two are clearly marked as bad options. However, despite showing an optimal 135° angle, the diagram indicating the correct posture is misleading. There are three problems with it. First, although the trunk-thigh relationship is 135°, offering potentially good lumbar support, the sitter’s neck is flexed forwards to a degree that might be detrimental to the cervical spine. Second, it is questionable whether a person sitting this way would be able to reach his or her desk to work or to

12 The Alexander Technique is based on the teachings of Frederick Alexander and the principle that “all vertebrates initiate action with their heads” (Cranz, 2000, p.126).
be able to see things on it properly. Finally, people working at desks have been observed to sit leaning forwards and backwards and somewhere in between, depending on the task and chair. (Chaffin et al 2006 p208) It could be argued then, that a person carrying out office related tasks might at some time use any of the postures shown. Note, that the backrest is the only feature that has been altered, the knees remain fixed at 90° in each image. These issues highlight the importance of understanding the chair’s use in the context of its intended setting.

![Figure 2.10 Thigh torso angles and seated postures in office chairs](http://news.bbc.co.uk/1/hi/6187080.stm) [Accessed 22.02.16] original in colour

Although conventional chair designs are not conducive to achieving the open angle posture there are examples of products that encourage this way of sitting. Manufacturer Bambach (Figure 2.11) has a seat that is similar in shape to a horse riding saddle set on an office-style five-star base. Gandavadi et al, (2005) reports that sitting on this type of seat, and consequently having a forward tilted pelvis, could have a positive effect on manual activity. This is a particularly interesting idea to consider when designing chairs for primary schools where writing practice is currently a daily activity.
A comparison between these types of seats, paired with adjustable desks, and conventional chairs and desks found those using the Bambach seat had a more upright posture (Saarni et al, 2007a). Furthermore Noro et al, (2012) report that a similar seat designed to replicate a “Zen” sitting style for surgeons was more comfortable to use than a conventional chair when holding static postures for extended periods of time.

Norwegian industrial designer Peter Opsvik’s book Rethinking Sitting (Opsvik, 2009) illustrates a diverse range of seating products. His often-playful approach to the design of chairs yields surprising and fresh concepts within the open angle and dynamic sitting realms. Explorations into “the borderline between sitting and standing” (p.122) or on maintaining movement in swing like seats (p.103) and the familiar Balans seat (sometimes known as the kneeling chair) demonstrate that Opsvik is willing to consider the human being’s relationship with the product from a less conventional and very human perspective. That his chairs are designed to accommodate a variety of ways of sitting represent a mind-set with a sensitivity to the needs of the individual person who will be the ultimate end user. Yet many of his designs are mass manufactured.
One of Opsvik’s particular interests has been in designing products that can adjust to suit a variety of sizes of user. The Tripp Trapp chair (Figure 2.12), designed in 1972 and still marketed today, has a seat and footrest that can be moved allowing the chair to “grow” with the user from babyhood to adulthood.

![Figure 2.12 Trip Trap Chair](source)

In summary, there is a preconceived and accepted notion embedded in Western culture about the functional and aesthetic qualities of chairs that is at odds with human anatomy despite their anthropomorphic sounding features; legs, arms, back, feet etc. (Cranz, 1998 p.65). The design heritage of seating owes more to demonstrating social conformity than to the users’ human form. This lack of connection between chair design and the end user’s physical needs is compounded by industry’s focus on process rather than utility. However, there are other approaches that can be applied to designing seats that take a more sympathetic account of the human user’s individuality by catering for different size or growth over time.

**Implications for the research**

Ergonomically a chair should be comfortable to use over time and provide appropriate user support for the task in hand. That generally the design of chairs is so deeply rooted in social and cultural concerns, as opposed to human needs, is problematic. For this research specific questions are
raised as to what our expectations are of school chairs in the 21st century. What should be the basis for the design of school chairs? Should the design of school chairs be based on social preconceptions of human behaviour or on the needs of end users?

2.4 The Historical Context of School Furniture Design
In considering the questions raised above on the ergonomic and social factors surrounding school chair design it is important to add context by exploring the historical origins of such furniture pieces. This will explain school furniture developments in relation to relevant key historical periods and will also discuss the origins of the currently accepted school chair design and its place within the context of current discourse.

School furniture design: 19th Century heritage
The 1870 Elementary Education Act established a national system of local school boards tasked with educating working-class children (Burke and Grosvenor, 2003). Following this, the earliest purpose built schools and the furniture contents were designed around a need to accommodate immense numbers of children. The London School Board region originally anticipated a requirement for 100,000 places. This was a huge underestimation and within thirty years more than five times that number had been accommodated. An initial lack of teachers meant that large schoolrooms housed children sitting on rows of benches taught by pupil-teachers under the supervision of one headmaster. Curtains, instead of walls, separated different groups of children (Seabourne, 1971, p. <16>).

Through integrating architectural and educational matters Robson’s 13 “School Architecture” (1874), provided detailed descriptions of different architectural and pedagogical styles from various European and American schools that he had visited. In order to inform those involved in creating

13 Robson was appointed First Architect to the London School Board in 1872 and travelled widely to study the educational practices in other countries such as the USA, Switzerland and Germany (Dudek, 2000).
schools, the book set out comprehensive recommendations embracing the exterior architectural details and playground equipment through to the smallest items of interior furnishings. Its publication ensured a widespread take up of Robson’s educational principles across the country (Dudek, 2000, p.12). Robson explained the “monitor” system of teaching where “one master could conduct a school of even 1,000 children.” (p.11). The pupils sat on rows of benches and desks in the middle of the room with a teacher at the front. At the sides of the room small semi-circular groups of pupils gathered to be taught by the monitors, who were pupils themselves. By way of contrast Robson’s ideal schools were modelled on the Prussian pedagogical style where each class had its own separate room, with a qualified teacher. These classrooms were built around a shared communal hall (p.13).

Robson’s recommendations were pragmatic, basing the allocation of classroom space on such practical matters as the distance a teacher’s voice could travel (allegedly around 11 feet) and the numbers of children that were to be accommodated (Dudek, 2000). In planning the classroom spaces, pedagogical needs (or Robson’s interpretation of those needs) were to the fore. Infant classrooms were required to be furnished with stepped galleries for the teacher to “see the face of each child” and vice versa (Robson, 1972, p.188). Desks were to be designed to help children concentrate by separating them from distraction by others (p.170), although primary school children were seated in pairs as this was seen to be more cost effective (p.171).

In short, the solid wood and cast iron furniture of 19th century schools was designed for the activities of “writing, reading and listening” and to maximize available floor space (Medd, 1995). Ergonomically Robson’s furniture specifications attempted to achieve the seemingly impossible:

“… full-size section should be carefully studied in every part, and adapted to the anatomy of the human frame in its varying sizes” (p.179).
Pupils were to have benches and desks designed “… not for sitting at or for standing in – but for both…” (p.169). Robson then goes on to discuss the difficulty of creating this arrangement. In his own words, “What is intended to suit everything generally succeeds well in nothing” (p.170).

However, pupils’ physical comfort (and their teacher’s) was important and the potential for uncomfortable seated postures distracting pupils from their studies was to be minimised. Seats were to be neither too high nor too low (p.362). Similarly, backrests were to be high enough for support but low enough not to interfere with moving elbows (p.185). Despite this apparent concern for comfort the heights of seats were determined by popliteal height (p.362), following the right angle paradigm of sitting with all the associated physical difficulties and no doubt the social connotations of the era. Children were to be shaped in mind and body; they were to sit and be taught.

By way of contrast, around the same time historically, an English chair manufacturer produced a chair with controls that could adjust the backrest height and angle and tilt of the seat to accommodate different sized people (Olivares, 2011, p.30).14

School furniture design: 20th Century developments
As an example of school architecture of the era, Glasgow’s Scotland Street School15, built at the start of the new century could accommodate over 70 pupils in its Victorian style stepped classroom (Figure 2.13). This was designed and constructed when there was little need for personal storage beyond the slates used for writing.

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14 “Unknown 2” was manufactured by CWS Keighley, England in 1885 (Olivares, 2011).
15 Designed by Charles Rennie Mackintosh for Glasgow’s School Board between 1903 and 1906 the building’s footprint reflects Robson’s Victorian school principles. Likewise, originally the classrooms were stepped.
A growing need for book storage space in the ensuing years saw the rows of benches replaced by individual desks with lift up tops and attached seats. These were less space efficient and by the 1960s the number of pupils that could be accommodated in the same space was reduced to a maximum of forty-five (Figure 2.14). However, the size of furniture produced did not always meet pupils’ anthropometric needs and this adversely affected pupils’ postures (Medd, 1995). Although the furniture design had changed since Victorian times the classroom layout retained the same traditional “regimented rows” of pupils facing their teacher who was positioned at the front of the class (Bendell, 1971, p.92). This was about to change.

The aftermath of the Second World War brought huge social changes with wide scale public sector rebuilding and development. This period also brought design innovation to schools through new construction techniques and more ‘child-centred’ educational practices (Woodham, 2012). The new school buildings and furniture were less formal and designed to facilitate new pedagogies concerned with “individual learning” as opposed to “[whole]… class instruction” (Bendell, 1971, p.92). School furniture had become lighter and easier to move, and flat, shared tables replaced sloped, individual desks.
Architects David and Mary Medd (nee Crowley\textsuperscript{16}) were at the forefront of this invigorating attitude towards the design of primary school architecture and furniture in the austere post-war years. David Medd’s architectural designs included lighting, heating and classroom furniture and “
breathed a freshness and optimism that caught the imagination in the years of austerity” (Saint, 2009). Early in her career Mary Medd discovered a user-centred approach to design and developed this as a means of informing her design process (Walker and Saint, 2005). Whilst employed by Hertfordshire County Council, the David and Mary Medd generated new concepts for modern schools by observing teachers working in traditional classrooms. Noting the multi-functional nature of schoolwork, the Medds’ school buildings replaced traditional classrooms with spaces that were more flexible and adaptable (Cullinan, 2013). These spaces required a different type of classroom furniture that was viewed at this time as an educational “tool” for teachers and pupils (Medd, 1984, p.15).

Whilst thrifty post war economics led to architectural concerns with space efficiency in the design of new schools (Woolner et al, 2007b) the ways in which school furniture was designed and purchased also changed. Manufacturers’ catalogues had been the furniture source for many schools. The range of available designs was limited and not always a good match for the requirement. However, some local authorities\textsuperscript{17} had sufficient resources to commission the design and manufacture of pieces to suit their own needs. This practice eventually led to local education authorities forming consortia to centralise the design and procurement (Mullery, 1971) and so well designed school furniture became more accessible to all schools.

Medd (1984) summarised the collective spirit of the time and its impact on educational facilities:

\footnotesize{\textsuperscript{16} Mary Crowley’s father, Ralph Crowley, was a medical professional with a keen interest in children’s all round welfare including their education and was an initiator of open-air schools in England in the early 20\textsuperscript{th} century (Burke, 2013).
\textsuperscript{17} An example being London and Kent County Councils (Mullery, 1971).}
“... administrators, educators and designers – both in local and central government – brought the users (teachers), the makers (designers/industry) and the policy makers (administrators/politicians) together in a single organisation in continuous association. It is this that enabled building to catch up with education, in so far as new buildings became not merely the old school in modern dress but something fundamentally different.” (p.6)

The buildings may have been fundamentally different and in many respects so was the furniture. The internationally successful FORME range of school furniture, illustrated by scale models in Figure 2.15, was a result of collaboration, led by David Medd, between two government departments\(^{18}\) and furniture manufacturer Pel\(^{19}\) (Bendell, 1971). Central government retained ownership of the designs and Pel licenced the rights to manufacture and market the products worldwide (Medd, 1984, p.15). With more than 150 items in the collection it is no surprise that there was an accompanying planning tool kit to assist teachers in arranging the spaces to suit their teaching needs “…exploring and illustrating the layout of furniture, the use of space, and the activities planned for children…” (Powell, 1976, p.3).

\(^{18}\) The Ministry of Public Buildings and Works (Supplies Division) and the Department of Education and Science (later the Department of the Environment) (Bendell, 1971).

\(^{19}\) Practical Equipment Limited.
The emphasis here was on designing for teachers’ needs, (although Woolner et al, (2007b) argue that these needs were informed more by advisors and head teachers), space efficiency and furniture arrangement. The most up to date anthropometric data was applied to furniture designs (Medd, 1984; 1995) to ensure that chairs and tables conformed to the pertinent British Standard. However, the needs of pupils, the actual end-users, were not considered beyond this. This may have been because children were expected to spend less time “sitting down en masse listening to the teacher” (p.91) and carpeted floor space was provided for this purpose. Also, because of the flexible nature of the space it was assumed that not every child needed a chair; so fewer were provided than there were pupils in the classroom (Barlow, 1971; Dudek, 2000). In taking a teacher-focussed approach this “total environment” concept (Bendell, 1971, p.93) of school design failed to consider more fully the pupils’ furniture needs in terms of task appropriate physical support. This reveals a gap in the approach, an oversight perhaps, but an important one for school children.

Figures 2.16 and 2.17 illustrate the types of furniture designed by Medd and demonstrate some of its ergonomic shortcomings by today’s standards. One boy (Figure 2.16), appears to be well suited to the size of the furniture but the other boy (Figure 2.17) appears too tall for both the chair and table; to enable him to see the work he is doing his neck is flexed to a great degree and his legs appear too long for the seat height and depth.
During the 1960s and 70s a broader curriculum required more versatile furniture, bringing an increase in sales (Medd, 1995). At this time designers from one of the newly formed consortia, the Counties Furniture Group\textsuperscript{20}, worked closely with manufacturers to keep abreast of technological developments. Contact with the Department of Education and Science ensured that the group kept pace with educational developments at the same time (Mullery, 1971). However, as Dudek (2005) maintains,

“… the physical form of most school buildings has barely changed since mass education was first established in its basic form at the beginning of the twentieth century.” (p.30).

It could be argued that the design of school furniture has changed very little since the 1970s.

As previously discussed (in section 2.3), in the design of chairs manufacturing methods have historically had more influence over human needs. By 1972, with the introduction of steel and plastic, the weight of school furniture was reduced without compromising strength. (Medd, 

\textsuperscript{20} The Counties Furniture Group, established in 1962 to design and supply affordable and good quality school furniture, remains in operation as a not-for-profit company controlled by a membership of eighty-one local authorities. (CFG, n.d.)
1995). The polypropylene chair was introduced “tougher, more comfortable and colourful than the wooden variety” (Barlow, 1971, p.92). An example of this is the E Series chair launched for the education market in 1972 by furniture manufacturer Hille (figure 2.18). This was to become the archetypal design for many school chairs and is still used today.

![Figure 2.18 The E-series chair](source: the author)

The product was a version of the Polyside chair, a 1950s collaboration between the widely known designer Robin Day and furniture manufacturer, Hille. Using a new type of plastic developed by Shell (Jackson, 2001 p.118) these chairs were designed to be manufactured in polypropylene, the relatively new, tough, yet inexpensive material (Hille n.d.). As Day said of the original design, “This chair arose from the need for a multi-purpose side chair at very low cost” (Jackson, 2001, p.118).

Although Day also stated, “Considerations of posture and anatomy largely determined the [form of the] sections through the shell” (Jackson, 2001, p.118) the design reflects the assumption that the person sitting will adopt a conventional right angle posture. This type of seat, as the basis of a design for school children, takes a narrow view of the concept of sitting and leaves plenty of room for improvement through a closer scrutiny of the needs of the end user.
By comparison, around the time that Hille launched the polypropylene chair for schools, the mechanism that has become commonplace for adjusting office chairs was introduced. A threaded mechanism for adjusting the height of office chairs had been employed since 1872, (p.179). In 1970, Wilkhahn\textsuperscript{21} introduced the pneumatic height adjustable chair (Olivares, 2011, p.43).

By the 1990s furniture was being bought (for schools by local authorities) through Supplies Organisations\textsuperscript{22} selecting products from catalogues. Competition to have products marketed in the catalogues, as the main access to Local Authority spending, drove the price of items such as chairs down - essentially commoditising them (Davies, 2015). School furniture was no longer seen as an educational tool, something that has become an enduring matter. A study, carried out in the USA, found that school furniture manufacturers relied on existing specifications for design information rather than carrying out new research and that subsequent designs remained largely unchanged (Lane and Richardson, 1993).

Dudek (2000, p.61) questions the practicalities of delivering formal education in an informal open plan classroom. He asks about the level of training student teachers receive on how best to utilise the classroom space. This is an important point because the classroom is their domain and they need to be able to make the space work for them, whatever their style of teaching. Ergonomic research on the negative effects of seated posture on school children has implications for teachers planning lessons as much as it has for furniture designers (Murphy et al, 2004). The furniture should be able to support different pedagogical styles as well as pupils’ ergonomic needs.

\textsuperscript{21} 232 by Wilhelm Ritz was manufactured in 1970 by Wilkhahn (Olivares 2011, p.43).

\textsuperscript{22} These included, for example: YPO, ESPO, Kent County Supplies and West Mercia Supplies (Davies 2016a).
School furniture design: 21st Century context

Events in the first decade of the new century should have resulted in a rethink of school (and school furniture) design on a par with that last seen during the post war era. Many of the schools that had been built in the post war era were now in need of repair or replacement (Davies, 2015).

In England significant investment in the Building Schools for the Future (BSF) programme, which later incorporated the Primary Capital Programme (PCP), was anticipated, not just to revitalise the schools estate but also to deliver new and transformative learning environments suitable for the 21st Century. BSF, initiated in 2003, was to upgrade and rebuild all secondary schools over fifteen years old with a budget of £45 billion. In 2006 a similar programme was introduced to refurbish or rebuild 50% of primary schools (Education and Skills Committee, 2007 p.28).

The ambition was to reform the organisation and design of schools along with the funding and distribution processes (DfES 2004). Expectations were that well designed and high quality school environments would consequently raise educational standards (Cardellino et al, 2009). In 2010 the subsequent government controversially halted both investment programmes. Unfortunately, despite a flurry of interest, there had been little enduring change to the design of school furniture during the period of the BSF programme and the PCP.

In 2002 Design Council research (Bond et al) found school resources, including furniture, to be inadequately designed and was highly critical of cost driven procurement processes and the limited choice to be found in catalogues (p.85). Furthermore, in the same report a case study of secondary school chairs found them to be inappropriate for the purposes of pupils and teachers (p.34). Despite this there was little incentive for schools to look beyond the polypropylene chair. A 200023 Department for Education and Employment procurement guide for furnishing classrooms,  

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23 At the time of writing these guidelines remain available on-line.
described polypropylene chairs as “… the most common form of seating found in schools…” listing their benefits as “… inexpensive, stackable, relatively easy to clean and lightweight…” (p.53); a hard to resist combination for those with tightly squeezed budgets. Although the ergonomic principles and advantages of adjustable furniture were explained in the document (p.63) this was done in relation to furniture for use with equipment in specialist ICT suites (Wadsworth, 2000) and not as an everyday requirement.

Together, the Design Council and the Department for Education and Skills launched “Designs for the Future”, a competition to bring innovation to school furniture design. One of the three winning products, Orbital (Figure 2.17), was the result of a collaboration between the designers Shin and Tomoko Azumi and manufacturer Keen (Booth, 2003).

Designed to suit the 360-degree classroom concept, Orbital consisted of a combined desk and chair unit (Figure 2.19). The seats pivot around the table enabling pupils to see the teacher anywhere in the classroom. The units could also be moved to allow different spatial configurations to facilitate group or individual modes of working. The seat was height adjustable; however, the shape of the seat was conventional, shaped to support right angle sitting with the accompanying physical implications for the seated pupils. Orbital was designed primarily from the pedagogical perspective, like Robson’s and the Medds’ furniture. How the furniture performs within the architecture of the classroom and how it assists the teacher’s needs was given greater consideration than the crucial interface between sitter and seat. Orbital was available on the educational furniture market for a few years but, despite having changed views on the flexible use of classroom space, the product did not sell in sufficient numbers and so was discontinued (Topliss, 2014).
During the same timeframe other organisations were also engaged in a quest to improve the design of school furniture. An early day motion in parliament called for schools to supply pupils with adjustable furniture (Burstow, 2006). The charity Backcare highlighted the consequences of badly fitting chairs with its campaign Protecting Young Backs and presented an economic argument for ergonomically designed chairs rather than plastic bucket seats:

“Ergonomic adjustable chairs may have an original outlay three times that of currently adopted polypropylene bucket chairs. Over a 25-year period, however, due to the sustainability of design and materials, the lifecycle cost of individual ergonomic adjustable height tables and chairs is actually 22% lower than the “budget” alternative” (Select Committee on Education and Skills, 2007).

In 2008 the Furniture Industry Research Association (FIRA) launched a multi-stakeholder call to action to bring the design and supply of school furniture in line with the BSF vision, stating “with the exception of polypropylene chairs in the 1970s, there has been no significant innovation in educational furniture in the last fifty years” (FIRA, 2008). FIRA also launched a certification scheme to award school furniture products that achieved high standards in ergonomics, safety, and environmental sustainability.
Medd (1995) relates that during the 1980s the European Committee for Standardization had difficulty in agreeing a European standard for school furniture. There was a lack of consensus on whether the conventional right angle or Scandinavian-style open angle posture should be supported; each would require the application of anthropometric data in a different way. The issue was resolved with the publication of BS EN 1729 1:2006\(^{24}\) (BSI, 2007)\(^{25}\). This offered guidance on sizes for tables and chairs appropriate to both postural outlooks and it also includes guidance for height-adjustable furniture. Anthropometric data from five European countries\(^{26}\) was used to determine different sizes of furniture divided into eight size marks. The document provides dimensional guidance to be colour-coded by manufacturers denoting to consumers the compatibility of chairs and tables. It does not specify actual designs, stating that:

“The dimensional requirements of this standard permit various interpretations of design; hence customs, educational practices, technical and financial circumstances of individual countries can be satisfied.” (BSI, 2007, p.4)

The seat height specifications contained in the standard (BSI, 2007) are based on popliteal heights indicating that chair designs using the information would support a right angle seated posture\(^{27}\). Although a UK National Annex\(^{28}\) (p.28) contains additional guidance and describes features of right angle and open angle seating. The section stresses the importance of providing the correct furniture for growing school children.

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\(^{24}\) Part one stipulates functional dimensions. Part two, BS EN 1729 2: 2012 details safety requirements and test methods (BSI, 2012)

\(^{25}\) Part one was superseded by the publication of BS EN 1729 1:2015 on 31\(^{st}\) December 2015.

\(^{26}\) Data sets from the following countries were used to establish guidelines: the UK, Netherlands, France, Italy and Germany.

\(^{27}\) A rationale in the most recent British Standard publication states that a seat height that is too high could cause pressure on the back of the leg that is bad for circulation. On the other hand one that is too high can cause the sitter to slouch by reducing the thigh torso angle. Both have the potential to impact pupils’ short and long-term health (BSI, 2015, p.60).

\(^{28}\) This annex does not appear in the most recent publication BS EN 1729 1:2015 nor is there any relationship drawn between size and age (BSI, 2015).
and explains the long-term health consequences of getting it wrong. It states that “most [school] furniture is purchased in the UK by age” (p.28) and data tables set out different furniture size marks in relation to school key stages and to children’s ages. This could be interpreted as implying that a child’s age can be used as a basis for size selection. However, it is countered by acknowledging that whilst using children’s ages to select furniture is “most convenient” it is also “the least accurate method” of sizes selection (p.28). There is a pronouncement on the long-term musculoskeletal health benefits of providing children with “adjustable chairs with the ability to tilt forward a few degrees, combined with adjustable tables with tiltable tops” (p.29).

Although this additional information on the consequences of children using badly fitting chairs is contained within the document it was, and still is, sufficient to demonstrate compliance with the standard by meeting the dimensional (and safety) requirements for chairs calculated on popliteal height. Consequently, there was and there remains little incentive either for a school chair to be designed that supports anything other than right angle sitting or, for an investigation into other requirements that pupil’s might have of their chairs. To design a chair that goes beyond pupils’ anthropometric needs the designer has to have the impetus to source different types of data that can reveal how educational furniture is used and to seek the opinions of those who come into contact with the products on a regular basis. As Mandal wrote, “The place to learn about schoolchildren’s problems is in the schoolroom not in textbooks” (1997 p.31).

The process to tender for BSF contracts was highly competitive, requiring main contractors to invest substantially just to assemble a bid (Davies, 2015). Costs for the provision of furniture, fitting and equipment\(^{29}\) (FF&E)

\(^{29}\) From the author attending the Safe Seats of Learning seminar in 2007 anecdotal evidence that furniture budgets were split between fixed furniture (that was included in the capital expenditure) and loose furniture, desks and chairs. Loose furniture budgets were not ring-fenced and so
was to be included in the bid and specialists were brought in to complete these. However, after contract award and the building projects were underway there were some inevitable overspends. Consequently, the money allocated to furniture budgets, and usually the last sums to be spent, had often been used up in contingencies covering overspends (Davies, 2015). Therefore, despite significant investment in educational facilities, the BSF programme made little difference to the design of school furniture and school chairs remained largely unchanged.

In comparison to the post war era the BSF process for bidding on and delivering projects placed an emphasis on the architectural spaces. That the post war era succeeded in implementing the kind of educational transformation that the BSF investment may have aspired to could be attributed to a collective spirit of the time, described by Medd:

“Novel administrative ways were found of uniting a consortium of local authorities, first through central government (which had the legal ownership of design), and eventually to a private manufacturer (who had sole legal right to manufacture and market the furniture world wide). This was an interesting example of uniting the user, the designer and the maker in a single enterprise...” (Medd, 1995).

This sense of unity was missing from BSF projects. School staff and pupils were supposed to be consulted as those best placed to describe the requirements of a good learning environment. In reality there was often insufficient time for them to be engaged effectively in the planning stages (Education and Skills Committee, 2007, p.3). As participants in the design process, pupils’ expectations were not always met because they were just one part of large-scale, multi-agency projects working within tight timeframes (Newman and Woodcock, 2009; Besten et al, 2008). Children’s contributions were limited in the amount of time that they were given to contribute (Education and Skills Committee, 2007, p.17) and in that their views were sought for communal areas but not for the classrooms where they would spend most of the school day (Besten et al, could be and were used in contingencies resulting in many schools taking old furniture into newly built or refurbished classrooms.
Yet historically\textsuperscript{30}, when pupils’ opinions have been sought on how their school environments can be improved, they have asked for more comfortable classrooms chairs (Burke and Grosvenor, 2003).

In 2002 the Design Council (Bond et al, 2002) reported that procurement of school supplies was driven by what was available on the market “... the teachers and the students are just reacting to the objects that surround them” (p.35). As far as school furniture is concerned there is little to indicate that this has changed in the intervening years.

**A Contemporary Context of School Furniture Design**

English schools vary significantly in architectural style. These range from Victorian school buildings, to post Second World War constructions, through to those that have been remodelled or redesigned more recently. However, regardless of the architectural style, there are common elements shared by most schools, such as the structured grouping of children by age (Dudek, 2000 p.41) and a national curriculum (DfE, 2013).

Pointon and Kershner (2000) observe that common characteristics of English primary school classrooms are so familiar to those “with experience of other classrooms” that as settings for teaching and learning they remain largely unchallenged (p.117). Within the space of a classroom different modes of teaching take place; for example, reading can be a whole class experience, or it can be a group, a one-to-one, or an individual activity (Dudek, 2000, p.49). Educational initiatives have an effect on the way that furniture resources are used; for example, the Literacy Hour introduced in 1998, “requires rapid shifts between whole class teaching and group work, with associated complications for seating arrangements in the classroom” (Kershner and Pointon, 2000).

\textsuperscript{30} A competition, run by the Observer newspaper in 1967 and repeated by the Guardian newspaper in 2001, asked children to describe “The School I’d Like”. Children in both competitions complained about the lack of comfortable chairs in their classrooms. (Burke and Grosvenor, 2003)
Capital investment in schools has undergone a review and in more recent, and austere, times a continued effort to replace the dilapidated post-war schools estate (Davies 2016a), the Priority School Building Programme (PSBP\textsuperscript{31}) has set about rebuilding or refurbishing the schools most in need (EFA, 2015a). Capital funding for schools being built or refurbished today does not include a provision for loose furniture (Davies, 2016b) meaning that schools have to either keep their existing furniture provision or, allocate money for new furniture from within their own operational budgets.

The primary school baseline designs\textsuperscript{32} and accompanying (non-statutory) guidelines\textsuperscript{33}, although intended for flexible application, seem set to perpetuate the ways that these classrooms are configured and used. Illustrative floor plans look remarkably similar to Victorian school designs where a long corridor leads to individual classrooms and a shared hall facility (Figure 2.20).

\textsuperscript{31} The PSBP was established following a 2010 review of capital investment in schools. In 2012 it was announced that 261 schools were to be rebuilt or “have their conditions met” by PSBP funding. (EFA, 2013)

\textsuperscript{32} Baseline designs set out adaptable building plans that can be achieved within the stipulated space and cost allocations (EFA, 2014a).

\textsuperscript{33} Building Bulletin 103: Area Guidelines for Mainstream Schools, to help draw up design briefs for new school or refurbishment of existing schools (EFA, 2015b).
Woolner et al (2007b) make an important point in stating that:

“... it is not clear whether new directions in teaching and learning should lead innovation in school design or whether innovative design will shape educational practice” (p.237).

On the one hand there is potential for creative thinking to get in the way of educational practicalities and, on the other, there may be insufficient time for discussions with end-users and a concern about what might emerge from the consultation process. A balance is needed to establish practical designs that would work in different contexts (p.237).

The government guidelines (EFA, 2014) for use by those involved in creating new, or refurbishing existing, schools recommend that a classroom or class-base for primary school pupils contains, among other elements, “adequate table space, generally arranged in groups” (p.15) and provides “free floor space, usually on a carpet area, for gathering the
whole class together sitting on the floor, for teacher-led instruction, group discussion, literacy, numeracy, storytelling” (p.16). Although intended as a design guide this information could predetermine a particular teaching style. There is little here to stimulate innovation and little incentive for architects, designers, or main contractors to refer to the schools’ intended end users.

Many common classroom characteristics may be taken for granted (Pointon and Kershner 2000). However, in sharp contrast to the commodity status of school furniture, new technologies are imbued with having transformational qualities. In the BSF era the Department for Education and Skills saw information and communications technology (ICT) as “an agent for change, enabling teaching staff and pupils to transform the way they work” (Education and Skills Committee, 2007, p.40). As discussed earlier and by reference to Victorian and Post World War 2 developments, school furniture has been historically designed around the predominant pedagogical style of the era, and with a prevailing logic that did not account sufficiently for either comfort or new pedagogical aims.

Although new styles of furniture have been introduced over time, such changes have been few and far between. There appears to have been more end-user emphasis in school furniture design requirements, and design innovation, in the post- Second World War era when budgets were minimal than in the more plentiful BSF years. However, it is arguable that the gradual commoditisation of school chairs has contributed to them becoming one of Pointon and Kershner’s (2000) familiar classroom features, or archetypes, that remain unquestioned by all those who come into contact with them. The classic, and inexpensive, metal-legged polypropylene chair fits neatly with this mind-set. Most importantly, the capacity for furniture to support primary school pupils in anymore than the

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34 For example: the unit cost of a Hille chair, modelled on Robin Day’s original design suitable for primary school use (seat 310mm high), is £12.99 (Education Supplies, 2016).
most basic way - providing a place to sit and to work - remains largely uncharted territory, practically and theoretically.

School furniture is just one part of an entire material school environment and all the elements should be well designed. In a UK study, Barrett et al (2013, 2015) found that good quality, ergonomically designed and age appropriate school furniture, was one of a number of environmental factors that had an impact on primary school pupils’ attainments. The study took account of many different environmental factors (Barrett et al 2015, p.130). However, beyond the broad description of “ergonomic” and “age appropriate” there is no information on either, how the furniture was used in the classroom or, how well it supported the end users’ - the teachers’ and pupils’ - requirements. There is limited scope for improving the design without more specific information.

In a study comparing activity levels of German and Irish school pupils the German schools used “dynamic, ergonomic chairs that allowed for the children’s natural movements to occur while sitting” (Burns et al, 2015, p.39). This is a reflection of a more tolerant outlook towards children’s natural inclination to move. Contrary to typical Western pedagogy, where an association is drawn between sitting still in schools and good behaviour (Breithecker, 2006), movement is seen as beneficial and not a behavioural issue. The research on dynamic sitting and moving classrooms carried out in Germany, by BAG and discussed in section 2.2, highlights the latent benefits for children’s education and health that could arise through school furniture being designed to incorporate natural movement and through an accompanying moving classroom pedagogy.

UK government guidelines recommend that children and young people between the ages of five to eighteen years old spend a minimum of one hour engaged in vigorous activity at least three times a week. The benefits being: improved cardiovascular health, maintaining a healthy weight, improving bone density and self-confidence. Additionally, it is recommended that the amount of time spent sitting should be minimised
(Department of Health, 2011). Furthermore, a national curriculum physical education lesson’s aim is to help children in primary schools maintain health and fitness (DfE, 2013).

A Public Health England report (Brooks, 2014) establishes connections between educational attainment and being active, healthy and wellbeing:

“Pupils with better health and wellbeing are likely to achieve better academically…. A positive association exists between academic attainment and physical activity levels of pupils” (p.4).

In light of these associations it is argued that well designed furniture that allows pupils to move freely (and an accompanying pedagogical approach) should be seen, like new technology, as having potential to enable education. The basis for the design, evaluation and selection of school furniture should follow Pheasant and Haslegrave’s (2006) ergonomic requirements in being appropriate for the user and the task-in-hand but should also accommodate children’s natural and healthy inclinations to move. Design, evaluation and selection should not simply be judged on price. This would need long-term research but it is worth the investigation as it could have long-term implications for education and for wellbeing. However, for the time being a health promoting educational ethos similar to the German style moving classroom, as described in Section 2.2, is unlikely to be introduced by UK schools or to be pursued by those who currently make or influence educational policy. It would take a concerted effort by all those involved to instigate a change.

Concern about learning time being lost because of pupils’ disruptive behaviour in schools prompted an Ofsted study on “low-level disruption” in the classroom (Ofsted, 2014). Although low on the list, pupils’ “swinging on chairs” was reported to be one of the main types of disruptive behaviour (p.8)\(^\text{35}\). In response to this report the government appointed a

\(^{35}\text{Reported by 11% of teachers who took part in the study. (Ofsted 2014, p.8)\)}}
teachers’ advisor on how to tackle disruption in classrooms (Morgan, 2015). However, there is no indication of an impending investigation into why children “swing” on their chairs. Swinging on, or tipping chairs in school is regarded as bad behaviour (Cullis 2010, p.201) and two out of three teachers indicate behaviour management as a factor affecting the organisation of classroom-seating (Pointon and Kershner, 2000). Yet as discussed in section 2.2, a study revealed that tipping a chair is one way that a child would respond to seated discomfort (Knight and Noyes, 1999). On the one hand the government requires children to move more whilst on the other movement is interpreted as being disruptive.

The BAG perspective is that school is the children’s workplace (Breithecker, 2005) and should be subject to the same ergonomic requirements as the adult workplace. This interesting outlook invites a comparison between the bureaucracy surrounding the adult workplace and the school. For example, the Health and Safety Executive publish a fifty-four page document on office chairs requirements (HSE, 2011a) whereas school furniture is represented in a three page classroom checklist by one question on the furniture’s general suitability and state-of-repair (HSE, 2011b, p.2).

Irrespective of whether the level of spend on school furniture is correct, commercially the prospects for school furniture appear optimistic, as austerity measures do not appear to have reduced spending. The British Educational Suppliers Association “Resources in English Maintained Schools” annual survey of January 2015 reported an increased demand for furniture products, above predicted levels, and that primary schools were planning an increase in spending on furniture products in the following academic year (The Education Business, n.d.).
2.5 Critical evaluation of alternatives to the archetypal polypropylene chair.\textsuperscript{36}

There are variations on the classic polypropylene chair available for schools to buy. As commercial products mostly their design provenance is not revealed. Some are similar to Day’s original with tubular steel legs, others have plastic legs; some have four legs, others a cantilever or sled base or are a desk-seat combination. They may come in a wide selection of colours. Marketing material is full of superlatives describing, “spinal ventilation for superior comfort”\textsuperscript{37} “excellent ergonomics, comfort and a modern look”\textsuperscript{38} or more genuinely “classic classroom chairs”\textsuperscript{39}. The accompanying marketing images often illustrate the chairs’ stack-ability. They all meet the most basic requirement of a general-purpose chair in providing a place to sit.

There is a small number of alternatives and the ergonomic qualities of four examples of school chairs that are slightly different to the standard are discussed below. The design features are considered in relation to the different paradigms of sitting, as introduced and discussed in section 2.1. The products are Chair 2000, Max II, Newton, Ray and Node.

Chair 2000\textsuperscript{40}

Designed by Counties Furniture Group and made in six European standard compliant sizes Chair 2000 is the only one of the five presented here that is available in sizes, suitable for primary schools. The chair was the subject of a study (Knight and Noyes, 1999). Nine and ten year old

\textsuperscript{36} Commercial images of the products described below are subject to copyright so, in place of reproducing an image to illustrate the chairs, a link to the relevant website is included in the footnotes.


\textsuperscript{38} http://www.schoolfurnishedirectltd.co.uk/category-3281/SFD32016.html [Accessed 28.11.2015]

\textsuperscript{39} http://www.schoolfurnishedirectltd.co.uk/4-leg-chairs/SFDP35.html [Accessed 28.11.2015]

\textsuperscript{40} http://cfg.gov.uk/products_folder/seating_folder/chair2000.htm [Accessed 28.11.2015]
primary school pupils using the chairs were found to increase their “on task” behaviour by a modest 2% although the reason for this remains unclear.

Chair 2000 sizes are consistent with the EU standard seat heights for chairs with seat slopes between -5 and +5 degrees (BSI, 2007). This implies that they are designed for something more in keeping with right angle than open-angle sitting. However, the seat edges are rounded and “without high sides… so that children can change posture easily” indicating a disposition towards dynamic sitting. However, the back legs are angled to restrict a tipping action so not all movement is encouraged; this could be seen as a safety feature.

Max II

Launched in 2007, and designed by an ex-teacher, the Max II’s unique selling point is that it has been designed to prevent pupils from tipping their seats backwards. This could be seen as a positive step for pupil safety and classroom behaviour management. On the other hand, the chair is purposefully designed to restrict children’s natural and healthy inclination to move. It is available in two sizes, neither suitable for primary schools. Based on a visual assessment (it appears to have a rearward sloping seat) and its size mark compliance with the European standard for seats with +/- 5-degree slope (BSI, 2007), the design fits within the right angle paradigm of sitting. Marketing information on the benefits of this chair states that it affords: “Comfortable lower back support to encourage natural upright posture for children’s growing spines”. However, it could be difficult to assume a natural posture given the angle of the seat.

41 This was superseded in 2015 to include chairs with slopes between -5 and +7 degrees (BSI, 2015).
44 http://www.trustedsupplies.co.uk/classroom-furniture/classroom-chairs/dlb-max-ii-chair-h430mm-11-14-years.htm [Accessed 28.11.2015]
Furthermore, smaller and taller students might have to compromise their posture to be able to sit comfortably.

**Newton**

At the opposite end of the movement continuum the Newton chair affords “two natural sitting positions, a comfortable sitting position and by tilting forward a secondary position with a more upright posture” (Isis Concepts 2015), clearly placing it in the *dynamic sitting* realm. It also features a sliding seat and a footrest making it more adaptable for different sizes of pupils. However, its availability in two size marks, mean that it is not produced in a size suitable for young primary school children.

**Ray**

Ray is based on similar postural principles to Newton except the seat rather than the base is the feature that supports an *open angle* posture. The front of the seat deforms becoming a saddle shape. Although it is produced in a range of sizes there is not one small enough for Key Stage one primary classes. The retail cost is approximately seven times that of a conventional polypropylene chair.

**Node**

This product is a chair and work surface combination. There is personal storage space for a large schoolbag below the seat. The entire unit is on wheels and so can be moved about to enable different group configurations to suit the mode of teaching. Node is the result of collaboration between design consultants IDEO and furniture manufacturer Steelcase and was released in 2010. Node is of particular interest as IDEO are renowned for their human centred approach to design. IDEO’s “*empathetic*” design of Node was inspired by the need for a place for students to put their bags and to be able to “*fidget*” and move

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45 http://www.isisconcepts.co.uk/portfolio-item/isis-newton-chair/ [Accessed 28.11.2015]
46 http://www.british-thornton.co.uk/School-Furniture-News/ray-chair [Accessed 25.01.16]
around, hence a seat with storage space below, on wheels (Kelley, 2013). The mobility feature of the design facilitates flexible use of the classroom space to respond to different teaching needs. It would, therefore, appear to be in the domain of *dynamic sitting*. However, by replicating the familiar form of the plastic bucket shaped seat Node’s chair shell, the part in closest contact with the sitter, perpetuates a *right-angled* concept of sitting. The inspiration for its design was not based on a biomechanical assessment of seated posture but on pedagogical needs for flexibility in the way that space can be used in the classroom. Node was designed in the United States but is available in the UK. It appears to be produced in one size. The seat height in comparison to the EU standard indicates its suitability for 14 to 18 year old pupils.

### 2.6 Implications for the research

The aim of the project is to improve the design of primary school chairs. A critical analysis of information from the contextual review has revealed aspects relevant to the human experience of using chairs generally and, more specifically, school chairs. User comfort, or lack of discomfort, has been identified as a key factor for the design of a good chair.

To create a chair that fulfils this benchmark the designer needs to consider variable characteristics of the end user and the task they are engaged in, to determine appropriate designable chair characteristics. End user characteristics include information such as their subjective views and pertinent, objective, anthropometric data. This suggests that a collaborative approach with the end user is required. If this venture takes place in an authentic setting then the designer can also study and assess the demands of the task.

A critical evaluation of different approaches to sitting revealed that seated posture is socially and culturally entrenched and often unrelated to the biomechanical aspects of the end user. In schools this is particularly the case. Poorly fitting school furniture is shown to be a continuing problem
and is a factor that contributes to children experiencing back pain, with potential long-term consequences for their wellbeing. Information from the European standard contains useful safety information and anthropometric data but, on its own, contains insufficient information on how school furniture is or, should be used in the classroom environment. There is a lack of literature containing information on how specific primary school tasks affect children’s posture and therefore, what type of support school pupils needs. Furthermore, as school seating products are almost exclusively located in the right-angle paradigm of seated postures there is plenty of scope for researching school chair design with alternative postural paradigms.

Since the post war development period the design of school chairs has taken the form of a scaled down version of an adult chair. However children are not simply smaller versions of adults. They are developing beings with individual and different requirements from the support of a chair. This is an area open to design exploration in conjunction with participating pupils.

Resolving the design problem in consultation with the end user is not sufficient on its own to affect a change in the design of school furniture. The design problem certainly needs to be seen from an end-user's perspective but the finished article also needs to function in a school environment. The chair’s social setting within a classroom makes it a mediating factor in the central relationship between teachers and pupils. Furthermore, although a teacher doesn’t use the furniture in the same way as pupils, they determine its use and as a result school furniture has, in the past, been seen as a pedagogical tool. Currently, within education and the associated business and political community, it appears that school furniture is seen as a commodity.

The school chair is overlooked as an important manifestation of design and there has been little, if any, research on what type of support a primary school chair ought to be providing pupils. It is important that
school furniture affords good support not only to the end user but also that it performs well within the classroom space and supports the needs of teachers and the curriculum. There is scant research on what these could be in the UK aside from recent studies confirming that the furniture does not fit many pupils.

The literature review details physical requirements that people have of chairs and how this has been historically overlooked by social conventions on what good posture looks like and, by extension, on how children should sit in order to learn. These issues remain, in that the potential for furniture to contribute to children’s wellbeing has been overlooked. The health benefits of moving within a classroom, working at different types of furniture, could be explored to encourage a wider approach to getting children moving at school.

Different schools of thought on seated posture also have implications for the comfort of the end user. These can be used as a basis of chair evaluation by providing a means of understanding the level of biomechanical support a chair’s designable features could or should provide the sitter. This is an important matter for design consideration yet historically it has been influenced by social attitudes and manufacturing processes. Neither should be the basis of the design of a task chair for schools. The ergonomic body of literature appears to be the only one that sees the design of school furniture as a problem.

There is little known about how primary school tasks affect specific pupil-chair interaction that can be used to develop new products. Given the three paradigms of sitting, how well do current provisions support children and how can that pupil-chair interaction be improved? That chairs don’t fit a large percentage of the user population in primary schools is the extent of current knowledge. The field of school furniture design is an area that is wide open for design research to explore, to pinpoint where issues are, and to suggest how these may be overcome. This requires an understanding of the chair in its social setting and a method for collecting
the relevant data for this purpose. These matters will be discussed in the next chapter.
Chapter 3: Methodology

The literature and contextual reviews show that the problem of poorly fitting school chairs is a persistent one. They have revealed different paradigms of sitting that can be explored to search for designable solutions. The basic requirement for a chair in providing comfort, over time, for a given activity has been discussed along with the subjective nature of perceived comfort. Therefore, the research methodology has to establish a means of investigating and evaluating these aspects with primary school children. Furthermore, at first glance what appears to be a design problem has also been revealed as something greater.

Social and cultural ideas affect how people sit and in schools this is particularly the case. Although Victorian era and post-Second World War school furniture was designed around pedagogical requirements, recent funding in educational properties has had an architectural emphasis and educational furniture has become a commodity, judged by cost, rather than as something that can support learning. Consequently, the problem of poorly fitting school chairs is also one that exists in a much wider social and cultural context. This is the expanse that the research project needs to map in order to begin to resolve the original design problem.

In this chapter the theoretical position of the research will be discussed along with a rationale for the chosen methods. The research design is presented, including a methodology for data analysis. This is followed by details of the recruitment of research participants and research ethics.

3.1 Theoretical location of the research

Different philosophical traditions exist, concerning the nature of reality and how it can be understood. These distinctive epistemological perspectives influence the methodological framework underpinning a research project and the methods used to answer research questions. For example, “Objectivism is the epistemological view that things exist as meaningful
entities independently of consciousness and experience... ” (Crotty, 1998, p.5). Therefore, by adopting an objectivist approach, a researcher would strive to take the stance of an unbiased observer seeking empirical evidence by testing previously defined hypotheses. Whereas, in the opposing constructivist domain, theories emerge from empirical studies and researchers are immersed in the process, accepting that their subjective engagement is part of the data being collected (Flick, 2009, p.16). From this constructivist outlook people encountering objects attribute their own meaning to them (Crotty, 1998, p.42) thereby suggesting that a single object can have multiple meanings for the researcher to uncover. However, taking such an approach to research does not lack rigour because the researcher attempts to negate personal or professional bias by maintaining a reflexive position.

In this design research project the researcher is also the furniture designer and so has a dual researcher and creative practitioner role. This brings associated biases and a subjective perspective of the research process, as described by Gray and Malins (2004) below.

“In the role of ‘practitioner-researcher’, subjectivity, involvement, [and] reflexivity is acknowledged; the interaction of the researcher with the research material is recognized [sic]. Knowledge is negotiated – inter-subjective, context bound, and is a result of personal construction. Research material may not necessarily be replicated, but can be made accessible, communicated and understood. This requires the methodology to be explicit and transparent (documentation is essential) and transferable in principle (if not specifics).” (Grey and Malins, 2004, p.21)

Mandal (1997) states: “The place to learn about schoolchildren’s problems is in the schoolroom not in textbooks” (p.31). The research object of change, the school chair, exists in a particular social context that influences how it is used. Mitchell (2011) describes everyday artefacts, such as those found in a school, as being “… the social accessories of institutions and everyday life that are imbued with history and with meaning…” and also implies that this meaning can be both “…personal and collective…” (p.36). Individual pupils use the chair when they are
engaged in school related tasks. The class teacher decides on the nature of the task including how, where and when it should be carried out. Subsequently, for the purposes of this project the teacher is also seen as a user (or designer of learning activities influencing use), albeit a secondary one. Pupil, teacher and chair are all contained within the spatial architecture of the classroom, which is bound within the school’s social system and its related practices. In its entirety this represents the context in which the chair, the object of change, is used. Therefore, although the study centres on the pupil and his/her relationship with the chair it would be a mistake to see the chair in isolation, as there are other complex factors affecting how and when the chair might be used. In order to design new concepts applicable for this situation the school chair needs to be viewed and understood within this complex context of use that is its natural, or real world, setting.

A requirement to understand the significance of the school chair in its socially constructed setting is indicative of an “applied ethnographic” methodology (Norman, 2013, p.222). Ethnographic methods, stemming from anthropology, are used in design to understand “cultural practices” by examining “designed objects” and can also be used to realise the effects that “designed objects” have on a culture and its practices (Crouch and Pearce, 2013, p.84).

According to Crotty (2013) an ethnographic study “… seeks to uncover meanings and perceptions on the part of the people participating in the research, viewing these understandings against the backdrop of the people’s worldview or ‘culture’ ” (p.7). Researchers adopting an ethnographic approach will immerse themselves in the target community to capture and record an in-depth experience “uncovering meaning” in a natural, real world, setting (Robson 2011, p.144).

The problem to be addressed was defined in the contextual review, Chapter 2, as an issue that has been consistently highlighted by ergonomic research. In this way it appears to be a problem in the
designed interface between the chair and the sitter. However, regarding this solely as a problem to be resolved with a new design would be too simplistic because the primary school chair exists in a social environment that can affect all aspects of its being. This real world setting holds clues to addressing the design problem. Tackled as a social or “wicked problem” (Rittel and Webber, 1973), it can be redefined as multifaceted and potentially open ended.

The solution is now not one new chair design that can revolutionise school furniture. Instead the approach needs to investigate and understand the many different aspects of the issue and in doing so can show where incremental improvements can be made at each level. Dealing with wicked problems requires a designer to be solutions and user-focussed rather than problem focussed (McDonagh, 2006). Methods for this type of research need to have the capacity to gain insight into the social and cultural aspects that could impede the successful implementation of a good design from the end users’ perspective. Also, data for design purposes has to be able to convey the pupils’ subjective experience of using the chairs as well as illustrate the postural implications of a chair in use.

**Human-centred design**

Research has always formed a part of the product design process whether, for example, exploring new technologies, materials and manufacturing processes, or using data generated by market research and ergonomics. Actively involving users, however, has not always been part of the process (McDonagh, 2006). Human-centred design (HCD) methodology has developed as a design/research domain through a need for technology (computer) systems that meet complex human needs. As a way of developing new products it is demanding on resources, it is time consuming to conduct and it relies on the availability of willing human participants. However, when it is important to understand human needs,
HCD provides a methodological framework for gaining insight into others’ perspectives.

More importantly, by not being exclusively end-user focused it also leaves latitude for investigating and accommodating the needs of a range of potential stakeholders to be included in the study; the users can be categorised as primary, secondary or tertiary (Chamberlain, 2010). This gives scope for the research to incorporate the views of those involved in purchasing school furniture, as tertiary users for example, and so adds to the rich construction of meaning surrounding the chairs by bringing a different perspective from that of the pupils as the primary users, or teachers, as secondary. Research for HCD can be differentiated from market research by centring on establishing “users’ needs” as opposed to “what people will buy” (Norman, 2013, p.224). However both of these aspects need to be understood for a product to succeed in a commercial market place (p.226).

Advantages of this approach are summarised in the following extract from the British Standard on Human-Centred Design for Interactive Systems:

“This approach enhances effectiveness and efficiency, improves human well-being, user satisfaction, accessibility and sustainability; and counteracts possible adverse effects on human health, safety and performance.” (BSI, 2010, p.vi)

The standard outlines six main principles of a human-centred design. Although these concern the design of computer interfaces the principles are transferrable to product design and are outlined below in table 3.01 along with the corresponding project activities.
<table>
<thead>
<tr>
<th>Six principles of human-centred design</th>
<th>Project Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Explicit understanding of context of use</td>
<td>Observing user, task and product relationships with field research in a school (real world setting)</td>
</tr>
<tr>
<td>2) Users involved throughout design and development</td>
<td>Seeking to gain users’ insight and evaluation of products throughout the process</td>
</tr>
<tr>
<td>3) Design driven and refined by user evaluation</td>
<td>Design practice-based participatory approach</td>
</tr>
<tr>
<td>4) Using an iterative process</td>
<td>Iterations of participant observation and consultation, idea generation, making prototypes and observing them being tested with participants, etc.</td>
</tr>
<tr>
<td>5) Addresses the whole user experience</td>
<td>Taking account the end users affective and physical experiences</td>
</tr>
<tr>
<td>6) Multi disciplinary design team</td>
<td>Taking a multi-stakeholder view and evaluation of data in consultation with other professionals, e.g. a physiotherapist</td>
</tr>
</tbody>
</table>

Figure 3.01. Principles of HCD and the project activities  
(Adapted from BSI, 2010, p.5)

Norman (2013) describes the human centred design process as consisting of cyclical phases of observation, idea generation, prototyping and testing (p.222). In carrying out design research the designer is seeking to understand "... the nature of the problem itself" (p.222). This is an important point in that clearly defining the actual problem to be resolved should be the first step towards resolving the design problem. It is important to enter field research with an open mind and take a broad view of what the anticipated problem actually might be. This could relate to a grounded theory study where theories emerge from the data gathered during the research process (Crotty, 1998, p.78). However, in this instance theories on seated posture have already been identified by the contextual review and tested during field research. Therefore the entire research strategy does not strictly adhere to this grounded theory approach.
A human centred design research project has similarities to an ethnographic methodology in aiming to understand and interpret meaning in a socially constructed world, viewed from another person’s perspective. This was judged to be particularly useful in this instance because the pupils, who are the chairs' end users, do not buy the chairs for themselves. However, HCD also uses this viewpoint to define the essence of the actual problem and to develop and refine solutions (prototypes) through an iterative process.

Taking a participatory design approach in a school environment has potential problems as revealed by Woolner et al.\textsuperscript{48} (2007b) but also can have potential benefits for those partaking. Pointon and Kershner (2000), for example, report that participation in classroom-based research can give teachers insight into “their own principles” (p126).

Children as research participants
In carrying out research with children there are complex issues around the balance of power between an adult/researcher and a child/participant, (Shaw et al, 2011). Although, Haudrup Christensen (2004) argues that this is not necessarily related to the adult-child relationship but is instead

\textsuperscript{48} In this case the designers were briefed to resolve a school’s storage problem. Pupils were active participants and contributed their thoughts. One pupil’s proposal was an intriguing drawing of an amphitheatre like environment, which led to the project being repositioned as a teaching experiment to test a 360-degree classroom concept. The shift in emphasis from a storage problem to one requiring new methods of teaching had continuity issues. It took time to set up and the teachers eventually testing the space were not those who were familiar with the project’s objectives at the outset. That left them unprepared for the new pedagogical style required by the reconfigured space. Furthermore, the pupils found the furniture, a seat and desk combination, uncomfortable to use. The project was discontinued after two terms, citing difficulties with balancing the needs of teaching and learning with the processes involved in trialling the environment including administering pupil feedback. This could be described as “mission creep”, where the original purpose of a project is redefined and eventually lost in the process. It is not clear from the report if the schools’ storage issues were ever resolved. (Woolner et al, 2007b).
imbued in the research process that, for example, depends on the cooperation of willing participants.

Children’s inclusion in research is indicative of an intention to give voice to their opinions (Yates, 2010). The degree, to which they become engaged as participants can be viewed on a continuum, conceptualised by Hart (1992) as a ladder 49. Those positioned on the lowest rung are seen as being “manipulated”, pawns in a process to meet adults’ objectives, whilst at the other extreme, on the highest rung, they are the instigators in a democratic process (Hart, 1992). Children’s level of inclusion can depend on how they are socially perceived. Historically this has been as less competent “human becomings rather than human beings” (Holloway and Valentine, 2000, p.763). More important is the ability of a child to participate actively and this may vary depending on factors such as age, culture and individual character (Hart, 1992). The means of communication therefore, needs to be appropriate for the participant group (Clark, 2010).

Prout (2001) attests that the incorporation of children’s views along with those of adults deepens understanding of the matter by drawing attention to aspects that would not otherwise have been noticed or articulated. In addition, children can bring a fresh perspective to social research through having common ground though they also have multiple differences, such as social class, gender or ethnicity.

Although there has been scepticism about children’s inclusion in research (Prout, 2001) their human right to express themselves on matters affecting them has been enshrined by the United Nations (UNCRC, 1992, articles 12 and 13). Ethical principles also apply to research with children (Hammersley and Traianou, 2012). The matter of research ethics is discussed in more detail in section 3.5.

49 A metaphor borrowed from Sherry Armstrong (Hart, 1992).
Children are driven by internal optimal stimulation causing them to engage experimentally with the world around them. “Confined only by their imaginations and developmental capabilities…” (Brown and Beran, 2008, p.30). Testing objects and themselves, often to extremes, is how they learn about themselves and their surrounding world. This also makes them unique candidates for collaborative creative ventures. In design projects where children are representing a user group as informants rather than being partners in design of products their participation can be woven into iterations of the design process around the adults’ activities (Kelly et al, 2006). In this way children can express themselves as experts in their own experiences (Clark and Moss, 2011) and their involvement in the design research process is important, even if they are not the experts in the process of design. Their role can be as client (Sorrell and Sorrell, 2005) or as participants in knowledge construction (Clark, 2010). As a research methodology the Mosaic Approach (Clark and Moss, 2011), developed to understand young children’s social experiences, shares a human-centred design outlook by seeking to understand people’s needs.

There are five important practicalities to consider in researching with children: access and gatekeepers, location and environment, power issues, feedback and dissemination (Shaw et al, 2011). These were addressed through the researcher building a good working relationship with the school community by helping in class on a regular basis before the field research began. The deputy head teacher was the senior gatekeeper and was kept fully informed of the research activities. Access to and availability of children for specific activities was by arrangement with the class teacher. Research activities took place in classroom spaces with which the participants were familiar. Issues of power can be more difficult to address, as the normal adult and child relationship in a school is that of teacher and pupil. However, the researcher attempted to address this by dressing informally, sitting at the same level as the children and by working at their speed. Participation was entirely voluntary and only then
with prior parental\textsuperscript{50} approval. There was clarity of expectation in that the participants were well informed of intended activities and were reassured that there were no wrong answers; that their opinion was valued. There were opportunities to talk to the whole class from time to time about the project and its outcomes. In the final year work associated with the research formed part of an annual art exhibition for the entire school community to view. Dissemination of the research outcomes is an ongoing activity. There are different audiences to be addressed however; the children’s active participation formed an integral part of the research.

The methods used to research with pupils in the classroom are discussed in more detail in section 3.2 and in Chapter 4.

\textbf{3.2 Methods}

The overall research question, described in Chapter 1, was to determine factors that would be revealed by taking a human-centred approach to the design of primary school chairs. This question sets broad boundaries within which the primary research took place, defining its theoretical location as well as denoting a physical location and the people and processes to be studied. A methodological framework for investigating the question was established by the real world location of the object of the study, the school chair, and the number of potential viewpoints that could affect its use. Ethnographic style data collection is time consuming (Robson, 2011). In this project the studies had to take place during the times that participants were available in their normal working day. This dynamic setting was best suited to a participatory and flexible study design (Robson, 2011). Although the main body of the investigation was carried out within the confines of one school, the flexible nature of the enquiry allowed the research process to evolve in response to findings in the field and to venture beyond the initial parameters.

\textsuperscript{50} In correspondence with pupils’ homes, the school referred to those with legal responsibility for the children as “parents and carers”. In this thesis they are referred to collectively as ‘parents’.
The research project was furniture design-practice based. Designing a furniture product such as a chair involves different activities depending on the aim of the project. For example, from an industrial design perspective the aim may be to create a particular chair form using specific materials. Day’s Polyside chair, discussed in section 2.4, is a good example of a chair designed with this end in mind. Alternatively, a craft-based design project may aim to use traditional methods to produce a chair for a contemporary market. In this project the design requirements were not concerned with the ultimate manufacturing process, material, aesthetics or marketing approach as a starting point. The aim was to determine how chairs could be designed to provide the best postural support for pupils carrying out typical primary school classroom activities.

Drawing on professional furniture design experience the researcher used methods that were appropriate to the phase of research and the particular area under investigation at the time. For example, visual research methods (observational drawing, photographs and video) were used to document participant observation including details of task related postures. Analysis and synthesis of visual research data and pupils’ anthropometric measurements then informed prototype development. Scale models were made as a means of designing a height adjustable prototype. The full-size version was tested and developed further in response to the participants’ feedback.

The practice of designing furniture was embedded within the research process and the emphasis at the time was on enhancing user experience. However, it is acknowledged that for a design to come to fruition the manufacturing processes would eventually have to be addressed.

In addition to the main research question, previously discussed in section 1.5, four sub-questions were set, primarily to determine data collection methods. The sub-questions also served as points of reference to ensure that iterations of the study could respond to findings and that the original purpose was not lost or overlooked by mission creep. From the onset the
priority was on establishing pupils’ needs and the overall research centred on the pupil-chair relationship. As the study progressed, and the teacher’s role emerged as equally influential, the focus altered and ascertaining their needs was incorporated into the study. As the classroom environment exists in a wider educational setting, opinions were also sought from other people who were considered to be influential in the ways that school chairs are ultimately used. The sub-questions were as follows:

1) What do teachers need from classroom furniture?
2) What do pupils need from classroom furniture?
3) What designable features could be identified and developed to improve ways of supporting these needs?
4) How are these needs affected by other influential peoples’ perceptions of the furniture, its use and their purchasing criteria?

The arrangement of the questions above suggests that the research was carried out in a linear fashion, with each question being investigating in turn. In reality, each question represents a separate line of enquiry and consisted of several iterations of data collection and analysis. Furthermore, the studies were dependant on the availability of participants so different studies often ran concurrently.

The intention was to gain insight into pupils’ and teachers’ lived experiences and to understand how wider social factors could influence them. Consequently, the research project was mainly concerned with qualitative data. However, specific, quantitative, anthropometric data relating to chair design and its application to school furniture design (Mandal, 1984; BSI, 2007 and 2015) was also gathered.

The setting and participants’ availability largely determined the way in which methods were employed and when. The researcher needed to remain flexible by responding to opportunities as they presented themselves and later by acting on reflections on events. Iterations of data collection, in particular with participating pupils, required lengthy ethical
procedures and organisation prior to commencement in the field. During this time the researcher became immersed in school life, and established a rapport with members of the school community, by helping in the classroom for a number of hours each week.

In other school research with participating pupils the class teachers have carried out the data collection (Woolner et al, 2007b; Cullis, 2010). To take this approach may have simplified the research process in part. However, in one particular piece of classroom based research (Woolner et al, 2007b) this eventually proved to be a burden for staff and was also seen as being potentially detrimental to the pupils’ education, mainly because the study was not relevant to the curriculum. Hence, in this project the researcher carried out all of the data collection with pupils although school staff assisted with administering the ethical process.

Chapters 4 and 5, comprise findings from different iterations of the study, and describe each of the research processes in detail. The methodology included visual research methods, observation, cultural probes, interviews and a reflective journal. Participatory research methods with children included observation, interviews, anthropometric data collection and prototype development. There follows a rationale for the methods describing why and how they were used.

Visual Research Methods
Visual research methods can be traced back to the late Renaissance period (Prosser and Loxley, 2008). Leonardo da Vinci was an early visual researcher making extensive use of “visual thinking” across his numerous fields of enquiry; his drawings recorded his observations, were a means of contemplating problems and also made his thought processes visible (Gray and Malins, 2004, p.93). Mitchell (2011) describes the use of visual research methods as having many purposes including: “… a mode of inquiry and representation, and as a mode of dissemination and engagement” (p.5). However, interpretation of visual data can be
challenging because images can mean different things to different people (Margolis, 2007). Furthermore, the validity of visual research can be questionable because images, for example photographs, present a “...particular view of reality...” and it is possible to alter such images making their use as objective representations problematic (Robson, 2011, p.371).

That said, the use of visual research methods can also reveal powerful cultural traits so deeply embedded in institutions, such as schools, that although “visible” they remain “unseen” (Prosser, 2007, p.14). Visual research methods are a valuable resource in revealing what Margolis (2007) refers to as the “hidden curriculum” in schools (p.11) by allowing for the scrutiny of behaviours and activities that might otherwise remain largely unquestioned.

Technological innovation has enriched the means by which visual data can be produced (Prosser and Loxley, 2008) and photography is central to visual ethnography (Mitchell, 2011). Visual data generated for research purposes can be created by the researcher and, or, by research participants (Prosser and Loxley, 2008) and can be supported by captions or explanatory texts (Mitchell, 2011). The researcher and selected research participants generated images for this particular research project. Drawing, video and still photography were used at different stages, with the latter proving to be the most effective, overall, in the field.

Drawings have been used to illustrate alterations to the classroom layout from year-to-year and sketches assisted in planning specific details of the prototype development. In the earliest phase of the research process drawing was also used to document pupils’ postures as they worked in the classroom. Drawing from observation develops visual awareness and is used to collect visual reference sources for design purposes (Schenk, 2014). Drawing from life requires editing what is seen down to the essentials. Initially, using the medium of ink on paper children’s postures were recorded. The pupils being observed were rarely still and so at times...
a diagrammatical approach was employed to capture a sequence of movements.

At the outset this slowing down of observation, to understand better the human experience, was seen as being fundamental to the research and design processes. An advantage of using drawing from life as a research method was anticipated to be in the simultaneous recording and analyses of observations in the field. As the project progressed however, it became more important to capture the pupils’ activity as a series of changing postures that could be analysed and interpreted later. Digital photography was a more efficient means of achieving this and so observational drawing was not used much beyond the pilot study. Video was also used early on to record movements; however its use was limited by a combination of research ethics requiring participant anonymity and technological limitations. In order to make participants anonymous video footage had to be edited frame by frame thus defeating its purpose.

Visual material was used extensively in this research project to document observations in the field, to engage participants in the research process, and to illustrate and to disseminate the findings of the research. A photographic database was built up over successive iterations of research with pupil participants and included images gathered in the classroom by the researcher and the class teacher. Still images from video footage form part of the collection. Digital images document pupil’s postures and the tasks that took place in the classroom; an additional advantage of digital photography was that the precise time that the image was created was also recorded. This facilitated time and motion sequences to be assembled and enabled children’s movement patterns to be studied in detail at a later stage.

Observation
Observation is a key ethnographic research method originating in anthropology (Robson, 2011, p.186). It is also a central method in
participatory design methods such as human-centred design (HCD) and in research with young children (Clark and Moss, 2011). As an HCD method, observation offers many beneficial attributes. Firstly, studying the object in context can clarify the problem that needs addressing. As noted above this is a key factor in the HCD process. Secondly, it provides information that can indicate how users’ needs might be met (Norman, 2013, p.221). In addition observing participants using prototypes is a means of evaluating how their needs are being met, or otherwise, during practical design development (Koskinen et al, 2011; Norman, 2013). Participant observation can be combined with interviews to validate findings (Flick, 2009) and can be overt or covert, but both have ethical implications (Crouch and Pearce, 2013). A drawback of overt observation as a research method is that participants may alter their behaviour as a result of being scrutinised. This is particularly the case if the researcher is previously unknown although the effect can be reduced by the researcher building rapport, for example, by assuming a voluntary role within the field of study (Crouch and Pearce, 2013, p.94).

As a research method in the classroom observation was used generally and specifically. Generally, the time invested as a voluntary helper in the classroom gave the researcher an opportunity to observe first hand ways in which the school operated, its daily activities and routines; although the main objective of being there was to form good working relationships with staff, and particularly with pupils. The school was used to having visitors\textsuperscript{51}. Supply teachers covered staff absences and student teachers gained practical teaching experience. A music teacher and IT teachers made regular appearances, afterschool clubs were run by outside organisations and parents were involved from time to time. All this facilitated the researcher’s integration into the community and consequently allowed for close observation of all manner of activities that

\textsuperscript{51} Note that this does not mean that people wandered in and out. There were strict controls over entry to the school premises and, early in the research process; the researcher was challenged when the visitors badge was not visible.
took place during the school day. These included everyday interactions between members of staff; or staff and pupils as well as other teaching staff, and occasionally supply teachers taking lessons. Assemblies and concerts that incorporated pupils from several different year groups were also observed. This level of scrutiny was helpful in gaining an understanding of the school’s procedures and its over-all ethos.

Observational activity mainly concentrated on ascertaining how and when school chairs were used in the classroom environment in relation to particular tasks, and participant dynamics within the space. More specifically, participants were observed when they were sitting down in the classroom and details of the physical child-chair relationship was recorded for evaluation; for example, the different postures children adopted when they were reading in pairs was noted. In the final year of the research a small number of participants were observed using a prototype chair to evaluate aspects of its design.

Observational findings were recorded mainly in photographs and noted in the journal. Drawings and video were used less frequently.

**Cultural probes**

Cultural probes are research tools used in participatory design methodologies. Originating in the Royal College of Art, cultural probes are a “playful” means of gathering detailed information about other people’s lifestyles (Gaver et al, 1999). Depending on the research aims, participants are supplied with a kit that might include any number of items for example: a notebook, a disposable camera, postcards, and maps. Over a fixed period of time those taking part can be asked to record images and thoughts on specific themes or events. The resulting material is used to provoke responses in a discussion between the participant and researcher (Gaver et al, 1999) and is a means of interpreting meaning from the data, thus gaining insight from the participants’ perspectives.
In this case a cultural probe style study was designed to establish the teacher's needs of the classroom furniture. A photography project was set and the teacher was asked to take photographs of the classroom furniture when, from a teachers' perspective, it was being particularly helpful or unhelpful for the activity in hand. After this event two separate discussions took place between the teacher and the researcher to review and discuss the resulting images.

**Interviews**

In an ethnographic research methodology interviewing participants is a complementary method to them being observed (Flick, 2009, p.169). Additionally, as a direct means of gathering another's views it can literally give “voice” to their experiences (Crouch and Pearce, 2013, p.112). This makes it a particularly valuable method in this research project where the main participants normally have no say in the furniture that they have to use in their classrooms.

Interviews can follow different formats as, for example, they can be structured, semi-structured or unstructured. Structured interviews have pre-established questions delivered in a particular order (Robson, 2011, p.279). This approach is useful in confining the scope of an inquiry to specific areas predetermined by the researcher and, as such, is not dissimilar to a questionnaire. In a semi-structured interview the researcher will again have particular topics to be investigated and a number of pre-established questions. However, the interview is also guided by the responses to those questions and so, as the exchange progresses, the direction can change in pursuit of new lines of enquiry (p.280). Whereas, in an unstructured interview, the least formal means of this type of inquiry, the discussion is allowed to develop around wide-ranging areas of interest (p.280).

As a means of investigating a variety of perspectives around one specific topic, semi-structured interviews offered this research project the
necessary focus whilst retaining a degree of flexibility to follow the lead from individual participants. In addition, and due to the real world setting, unstructured interviews also took place as conversations-in-passing between the researcher and members of the wider school community.

As the principal research participants, pupils were interviewed at different stages of the research. In one study this was facilitated by a book-making project shared with the researcher in an adaptation of a Mosaic-style approach to researching with children (Clark and Moss, 2011). Eventually, the interview process with pupils was distilled down to a more direct and concise question-and-answer session that proved to be more effective in getting on-the-spot feedback from children at work in the classroom. Chapter 4 contains more detailed descriptions of research methods used with pupil participants along with the findings.

The class teacher was interviewed twice as part of the cultural probe method, described in more detail above. The first meeting was to discuss photographs that she had taken of furniture and of pupils in the classroom. A subsequent meeting clarified points arising from the first and was used to discuss photographs that the researcher had taken of children in the classroom. Less formal conversations between the researcher and class teacher took place frequently in the classroom, discussing practical matters or points of observation; notes from these were recorded in the reflective journal.

Additional semi-structured interviews were used to assemble a wide range of perspectives on the subject matter by consulting with other influential professionals. This included from the school: the deputy head teacher, the business manager and the premises officer (with responsibility for purchasing furniture). External to the school, an occupational therapist was consulted, as were two university lecturers involved with training primary school teachers. Additionally, a physiotherapist was consulted on the content of specific visual data.
The interviews took place in familiar surroundings for the interviewees. In all but one case they were conducted face to face; the occupational therapist was interviewed via a Skype audio-link. Interviews were digitally recorded and transcribed by the researcher before being deleted to maintain the participant’s anonymity in line with ethical research processes.

Reflective journal
A reflective journal is a means of recording “practice based thought and action” (Gray and Malins, 2004, p.114). It can be used for “retrospective reflection” (p.22); to record field notes, document and evaluate observations and outcomes etc. It can also be used to make the design process explicit by recording thought processes.

Having been established as a useful research tool in the pilot study, the reflective journal was retained as a means of capturing a variety of aspects of the research. As well as being a place to reflect on events, the journal was also used in situ to record classroom observations. This included noting the types of tasks that children were engaged in, where these activities took place and the pupils’ associated postural adaptations. Details of research process and practicalities were also recorded. Planning notes listed equipment needed for different iterations of research and records were kept of data collected with individual pupils. The type of data gathered was textual and visual.

In addition to the reflective journal the researcher also used a sketchbook to store and annotate visual data. This was used to prompt discussions with interviewees and in the data analysis process.

Participatory methods used with pupils
As the principal users of school chairs, pupils played a central role in the research and gaining their insights was important as was obtaining data to determine their sizes for design evaluation purposes. Various methods
were used, such as overt observation and other more participatory activities including a short questionnaire, a book making activity, interviews and anthropometric data collection. Pupils were also involved in testing the prototype seat in development.

The methods of researching with children evolved in tandem with iterations of the project. The first line of enquiry was a pilot study to test and evaluate participatory research methods with pupils. The study used a short questionnaire derived from research on comfort with hospitalised children (Kolcaba et al, 2005). These were to investigate how comfortable the chairs and tables were to use and where the children preferred to sit in the classroom. The children answered the questions by choosing one of three stickers with different facial expressions representing “yes”, “no” or “maybe” alternatively, “agree”, “disagree”, “don’t know”.

In response to reflection on the pilot study methods, the subsequent study consisted of a book-making project, again with the aim of eliciting the children’s thoughts on where and how they sit in school. The Mosaic Approach to researching with young children was developed to understand their social experiences (Clark and Moss, 2011) and, as a methodology, shares a human-centred design outlook by seeking to understand people’s needs using drawing as one of a number of tools it employs. In an adaptation of this, making books was used as part of an informal interview technique and a means of engaging young child participants in conversation about the furniture. Bookmaking was a familiar activity in the classroom and one that the children enjoyed. The purpose was to investigate the children’s experiences of sitting in school, and particularly on using the school chairs, and in this instance bookmaking facilitated a conversation between the researcher and individual pupils. It was not being used for the children to design their own furniture although participants were asked to suggest improvements. This

52 A synopsis of the pilot study is reported in Chapter 4.
activity was carried out on a one-to-one basis and the conversation recorded for transcription.

In the final phases of the research, and in response to evaluation of previous iterations, the children’s views were sought much more directly in brief question-and-answer sessions, recorded digitally or in note form, as participants were working in the classroom. This method, used in conjunction with observation, was also used to collect the participants’ thoughts on the prototype while they were using it.

Anthropometric data collection
Qualitative, anthropometric data consists of human measurements recorded for use in designing products, tools and working environments (Chaffin et al, 2006, p.37). It is ergonomic information applied to a design so that people can use products with comfort and safety by ensuring a good fit between a user and a product (Norris and Wilson, 1995, p.2).

Collecting specific measurements from participating pupils provided an effective means of comparing their anthropometric data against dimensions specified in the British Standard for school furniture (BSI, 2007). The data was used to evaluate how well the current classroom chairs fit the pupils and to provide a basis for designing appropriately sized prototypes.

Pupil’s anthropometric data was gathered using equipment lent by, and procedures devised by, the Furniture Industry Research Association (FIRA) to minimise physical contact between pupil and researcher. The data collection process was similar for each child and followed FIRA’s procedure as closely as possible. Initially the procedure included measuring participants standing height, seated height, seated elbow height and popliteal length and height. As the research progressed this

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53 Both measurements require the participant to be sitting and correspond to the seat depth and height of a chair. Popliteal length is measured from
was reduced to participants' popliteal height and stature. The data collection procedure for these two specific measurements was as follows: Participants were dressed in school uniform. After ascertaining that each participant was happy to take part they were asked to remove their shoes before they were measured.

The anthropometric data collection equipment (Figures 3.01 and 3.02) consisted of:

- A rectangular classroom table
- FIRA’s Popliteal height measuring device
- FIRA’s Height measuring device
- A data sheet numbered for cross-referencing
- A tape measure

![Popliteal height device](image1.png)  
![Standing height device](image2.png)

**Figure 3.02**  
Popliteal height device  
Source: the author, originals in colour

**Figure 3.03**  
Standing height device

**Standing height procedure:**

1. The pupil stood with his/her back against the height-measuring device.
2. He/she was asked to stand tall and look straight ahead.
3. A visual check made sure his/her shoulders were level and relaxed.

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the lower back to the underside of the bent knee. Popliteal height is measured from the floor to the back of the bent knee.
4. The measure slide was positioned on the crown of the head compressing hair slightly to make gentle contact with the top of the head.
5. The height was read from the scale on the device and recorded to the nearest 10mm.\textsuperscript{54}

Politeal height procedure:
1. The pupil sat on the table and was asked to move until the table edge rested gently behind his/her knee.
2. The footplate was adjusted upwards until the pupil’s foot rested on it and the knee lifted slightly thereby indicating easing of pressure at the back of the thigh.
3. The footplate jig was secured in place.
4. The participant moved off the table.
5. The popliteal value was measured using a tape measure between the top of the footplate and the tabletop.
6. Heights were recorded to the nearest 5mm and noted on the data sheet. Before data analysis and in line with the British Standard a 25mm shoe allowance was added (BSI, 2007, p.28).

Prototype development
Developing and testing prototypes is an integral part of the iterative Human-Centred Design process (Norman, 2013). Prototypes are a way of making an idea tangible (Koskinen et al, 2011) and can be used to test an object at different stages in a design project from assessing user suitability to pre-production stages in evaluating manufacturing systems.

In the design process freehand sketches can be used to investigate and explain forms and ‘ways of making’. Technical, measured drawings

\textsuperscript{54} During the pilot study it was noted that different hairstyles made reading of the scale to exact millimetre difficult. Subsequent studies measured height to the nearest centimetre and popliteal height to the nearest 5mm. A tolerance of ±10mm is acceptable in anthropometrics (Pheasant and Haslegrave, 2006, p.42).
communicate object scale and manufacturing details. Computer-aided design (CAD) packages can be used to generate virtual products and photographic quality renderings; the latter are helpful commercially to show clients (Ballendat, 2013). CAD generated models can be used to test various technical aspects of three-dimensional products prior to manufacture. For example, engineering software packages can allow a designer to gauge mechanical tolerances by animating moving parts and by adding material properties; tensile strength can also be virtually tested. However, unlike a physical design prototype, none of the above can reveal how a person uses a product, what it feels like to touch, how it is perceived in real life, or how comfortable it might be to use.

### 3.3 Field research design

The table below, at Figure 3.04, represents an overview of the research design. Sub-questions are set out along with the corresponding data collection and evaluation methods, and the format of research outcomes.
<table>
<thead>
<tr>
<th>Research sub-question</th>
<th>Data collection methods</th>
<th>Data evaluation</th>
<th>Format of research outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) What do teachers need from classroom furniture?</td>
<td>Observation and a cultural probe style photographic project</td>
<td>Interviews to interpret visual data with the participating teacher</td>
<td>Visual data and textual transcripts indicating key findings</td>
</tr>
</tbody>
</table>
| 2) What do pupils need from classroom furniture? | Observation of pupils working to identify tasks and associated postural patterns | Relate findings to ergonomic literature also verification in consultation with clinical physiotherapist. | Visual: Photographs, video and drawings documentation  
Textual: Transcript of physiotherapist consultation |
| | | Thematic analysis | Visual: Thematic analysis highlighting key findings |
| | | As with observation above | |
| | | | Visual material, and textual transcriptions highlighting key findings |
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<th>Format of research outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3) What designable features could be identified and developed to improve ways of supporting these needs?</td>
<td>Collating data from above</td>
<td>Triangulation and synthesis of above data to inform idea generation and practical prototype development</td>
<td>Prototype development and testing prototype</td>
</tr>
<tr>
<td>4) How are these needs affected by other influential peoples’ perceptions of the furniture, its use and their purchasing criteria?</td>
<td>Interview of the school’s deputy head teacher, the procurement team and other external professionals</td>
<td>Triangulation with other data.</td>
<td>Contextual information for the thesis</td>
</tr>
</tbody>
</table>

Figure 3.04 Overview of the research design and outcomes. Adapted from Crouch and Pearce (2013, p.81)

**Data Analysis**

The assembled data was visual, textual and numerical (anthropometric) and, consistent with a constructivist epistemology, was interpreted in its different forms with the aim of “shedding light on meaning” as opposed to determining a particular cause (Robson, 2011, p.412). The studies detailed in this thesis were carried out to understand how things function in and around a social setting. This is a common goal of social research and of design research (Stake, 2010, p.122; Koskinen at al, 2011, p.75). As discussed above research sub-questions were used to establish methods and consequently the type of data to be generated. Data analysis was then conducted according to type and, more importantly, the purpose behind its acquisition. The analytical process was continuous and the research scope expanded, organically, in response to emerging themes.
Taking an ethnographic approach to research allows for “thick description” (Geertz 1993) that is to say providing rich details from the field (Flick, 2009) and, more significantly, “theory-based description emphasising the experience of those studied” (Stake, 2010, p.221). In accordance with the main focus of the project visual data was scrutinised with reference to ergonomic theories on sitting and seated postures. From a wider perspective data was analysed to expose cultural norms surrounding school chairs that are present but are not recognised.

The research process was iterative and specific details of data analysis are presented with each study in Chapters 4 and 5. Using the research sub-questions as a starting point the raw data was analysed to a) identify specific needs that could be translated into designable features for a school chair and b) to understand ways in which the social and cultural nature of its setting could affect the way it is used (that could also be pertinent to its design). Analysis of field research findings were used to inform and direct each iterative step in the research and ultimately in the prototype design development phase.

Interviews were recorded digitally on an iPhone 5s, and downloaded onto a MacBook Pro before being deleted from the phone. The researcher transcribed recordings and the resulting texts were analysed with regard to the relevant sub-question. Emerging themes were noted in a sketchbook along with relevant visual data. Recordings were deleted at the end of the transcription process.

Digital photographs, taken using an iPhone 5s, were downloaded into a MacBook Pro laptop before being deleted from the phone. After identifying features had been pixelated, in Photoshop, selected images

55 Geertz borrowed this phrase from philosopher Gilbert Ryle (Geertz, 1993, p.6).
56 This device was password protected to ensure that raw personal data was kept secure in accordance with the University’s ethical guidance.
57 A data transcription sample is at appendix 01.
were printed and added to a sketchbook and to a PowerPoint file for analysis and for discussion with selected research participants. Video was recorded on a Sony Handycam and, after being downloaded, was deleted. Still images were created from the video in iMovie.\(^{58}\)

Participants’ anthropometric data was added to Microsoft Excel for comparison to pertinent data from the British Standard for school furniture (BSI, 2007, 2015), producing comparative graphs. Anthropometric data was also applied to a prototype and used to test a seat height theory (Mandal, 1984) in the field. This process generated visual and textual data.

To demonstrate rigour in the research process and to minimise researcher bias, a strategy of triangulation (Flick, 2009, Stake, 2010) was applied throughout. Data was gathered from many different sources with a variety of perspectives, including different participants and methods. The findings from each study instigated deeper enquiry of emergent themes either by using another method, a different means of analysis or by consulting another person. For example, a theme such as the perception of comfort was investigated through the literature review, through primary research with participating pupils and the class teacher, and in consultation with a physiotherapist.

### 3.4 Participant recruitment

Adult participants were mainly members of staff from the school in which the research was carried out. The deputy head teacher, who eventually became a participant\(^{59}\), was active in sourcing individuals interested in joining the study. A children’s occupational therapist was recruited

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\(^{58}\) Any visual data not used in the thesis will be deleted on its final publication.

\(^{59}\) The deputy head teacher was the main point of contact at the school and was kept informed of activities associated with iterations of research. During these discussions it became evident that her input would be a valuable resource to the research and she agreed to become a participant.
through contact with a local hospital unit. Lecturers were recruited via a university teacher-training department.

The target age group for pupils, all between five and six years old, were in primary year one; a point in formal educational when children are expected to spend longer periods of time sitting down and concentrating on particular tasks. As a result, and in the context of school chairs, the year group was particularly interesting to study.

The participating children were volunteers from ready constructed social groups by being in the same class and year group in a school in the English education system. Because of this they would have had shared experiences of the school environment and its systems, including using the furniture, but, as individual people, they would also have their own perspectives on these common experiences to bring to the research project. Their differing subjective views and variety in physical size were of interest to the study. It was not concerned with other differences for example, gender, religious or ethnic backgrounds. However, the aim was to be inclusive and to take account of all willing participants regardless of physical or educational capabilities.

Research activity with pupil participants took place over three consecutive academic years but was always located in the same year one classroom. Each year a different group of children occupied the classroom. For the research to be ethical required both parental consent and pupils’ assent to allow participation in the project. This process also served as a means of participant selection.

3.5 Research ethics
Ethical considerations are an integral part of any research involving human participants. This requires that relevant ethical approval be granted prior to the research commencing. All aspects of this research project were designed and conducted with reference to guidelines from the
University of Brighton’s Faculty of Arts, Faculty Research Ethics and Guidance Committee (FREGC), and the British Educational Research Association (BERA, 2011).

For the purposes of this research project ethical matters pertaining to adult participants were addressed by applying the University’s Faculty of Arts Tier One process. This involved submitting a proposed plan and risk assessment for supervisors’ approval. Adults gave their informed consent to act as participants by completing a form which they had received in advance. 60

The research involving vulnerable participants or children, those under eighteen years old, was subject to Tier Two approval by the FREGC. Furthermore, research with children requires informed consent from parents (or carers) and informed assent from potential child participants. All involvement was explicitly voluntary and participants could withdraw, or be withdrawn by parents or carers, at any time without explanation.

Adherence to the Data Protection Act (1998) required participant anonymity, confidentiality and the safe storage and disposal of personal data.

Access to pupil participants
Access to the children was negotiated through two gatekeepers: the school’s deputy head teacher and the relevant class teacher. The deputy head teacher was kept informed of all the planned research activities with participating pupils. The time and place of actual research activities, including availability of particular pupils, was negotiated with the class teacher.

60 An example adult consent form can be seen at appendix 02.
Disclosure and barring service
As a requirement of those who come into contact with vulnerable people e.g. through work, volunteering or research the researcher had a valid Disclosure and Barring Service certificate.

Ethical Procedure
Each year a similar process was followed to ensure that the research adhered to the FREGC guidelines. This was achieved by obtaining the relevant parental consent and pupils’ assent before data collection began and by remaining mindful of the ages of the children participating and their safety and educational needs as being paramount. Children were assigned a participant number to preserve their identity and this was used to cross-reference different data sets.

For a number of weeks before data collection began the researcher spent time helping in the classroom to get to know the class teacher and to allow the children to become familiar with her presence. After a few weeks she had an opportunity to brief the children on the purpose of the project and planned research activities. A class discussion followed on “what designers do” and the different kinds of furniture in the classroom. The children offered their opinions and had time to ask plenty of questions. The voluntary nature of participation was explained and this was emphasised throughout the project with those who took part.

In accordance with FREGC guidelines, project information sheets and consent forms\(^{61}\) were circulated to parents via the pupils prior to the field research commencing. This is a typical means of communication between school and parents and the class teaching assistant helped with distributing and collecting the paperwork.

\(^{61}\) An example parental information sheet and consent form can be found at appendix 03.
The researcher was available to answer any parents’ questions at a specified time, date and place. As an alternative, parents were invited to contact the researcher, or a supervisor, by email with any questions about the project. During the three years of the research one child’s parents withheld consent but, as a rule, non-return of forms was interpreted as withholding consent.

As they contain personal information, in line with The Data Protection Act (1998), all consent forms remained in the school. Returned consent forms were initially kept in the classroom and were passed to the deputy head teacher for safekeeping on the school premises at the end of each study period. This data is to be destroyed by arrangement at a later date.

Pupils, whose parents had consented to their participation, were invited to take part in the assent process. Small groups were selected on their availability at the time and, in line with ethical guidelines, those taking part were informed volunteers. The information sheet was read to the assembled group by the researcher or, sometimes, one of the participants would read it to the group. Plenty of time was given for questions to be asked and answered before the sheets were turned over to complete the assent forms. Assent questions were read, one at a time, and discussed prior to children ticking the box of their choice. One child in the first year group and one in the third chose not to participate so they did not take part in the research.

An example child participant’s information sheet and assent form can be found at appendix 04.
Chapter 4: Findings from the classroom

Four research sub-questions, discussed in section 3.2, were used to determine the methods to be employed in iterations of data collection. These were also the starting point for the raw data to be analysed: a) to identify specific needs that could be translated into designable features for a school chair and b) to understand ways in which the social and cultural nature of a primary school chair’s setting could affect the way in which it is used (that could also be pertinent to its design).

In keeping with the ethnographic nature of the field, research findings are presented as a rich description (Stake, 2010) of visual and textual information with excerpts from interviews and field notes, as well as images63, to illustrate salient points and emerging themes. They are incorporated into this thesis as a means of making the research and analysis process explicit. They are also used here to illustrate points of discussion and it is acknowledged that each photograph represents an event in time, which may have been either fleeting or protracted. Personal bias has been offset by triangulating the data with other professionals’ interpretations of the images and by reference to theories arising from the literature review. On reviewing a collection of the photographs taken in her classroom the teacher commented, without prompt, that they presented “…a fair representation of what it is like every day.”

4.1 General procedural information
Pseudonyms have been used to protect participants’ identities; e.g. “Tania”. Quotations from interview transcriptions are in italics and inverted commas and use the interviewee’s pseudonym. The researcher’s speech

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63 Unless otherwise stated all visual data, photographic images and drawings, presented in this chapter record observations made during the research.
is indicated by “JL.” Passages taken directly from the field notes made during the course of this PhD are in italics.

Altogether forty-nine pupils took part in three phases of research in one classroom. In phase one, in July 2013, eighteen pupils participated in a pilot study to test and evaluate participatory research methods and processes. Their teacher, Penny, did not actively participate although the researcher observed her class and inevitably also observed her teaching. In recognition of this, and of the teacher’s role as a secondary user of school chairs, in the next iteration of field research the class teacher also participated. Phase two took place in the following academic year, in June and July 2014, with a new cohort of twenty pupil participants and their class teacher, Tania Cooper, a newly qualified teacher and a new member of staff. The third phase was carried out in the subsequent academic year, between December 2014 and July 2015. Tania was again a participant along with eleven of her pupils. The physical location of the research, in one of two adjacent year one classrooms, remained constant throughout all three phases.

Observation was a continual activity for the duration of the field studies. Prior to each participatory study the researcher took the opportunity to become immersed in the classroom culture as a helper. Primarily, this was to get to know the teachers and pupils and vice versa. However, this also presented a unique opportunity to learn about classroom practices and about the workings of the school.

Findings in this chapter are all related to research carried out in a working classroom. Specific procedures are described, relevant textual or visual data is presented, along with the means of analysis and implications of the findings for the research are discussed.

64 Although this was Tania’s first teaching position as a newly qualified teacher as a former pupil she was also familiar with many characteristics of the school.
4.2 Classroom tasks, activities and modes of working

Throughout the three-years of the research, time spent in the classroom provided the opportunity for observation and gathering of general data in response to the first two sub-questions:

1. “What do teachers need from classroom furniture?”
2. “What do pupils need from classroom furniture?”

Ergonomically, that a chair should provide a person sitting on it with comfort, over time, for a particular task was established in Chapter 2. Comfort can be affected by the variable characteristics of the sitter, the chair and the nature of the task in hand. The different types of task that children were engaged in were observed and data collected in a journal and in photographs. Photographs were also taken of the general classroom layout and resources. (Figures 4.01 to 4.05)

Figure 4.01
A classroom layout
Source: the author, originals in colour

Figure 4.02
The teacher’s workstation
During the course of the classroom observations different modes of teaching were dependent on the subject being taught, available resources and the particular task or activity that was to be executed. When activities, such as listening to the teacher, involved the whole class pupils gathered together to sit on the carpet; at other times they carried out activities, such as writing, at tables in small groups, sometimes with a designated adult. Pupils working in pairs frequently shared resources such as reading books and laptops\(^6\); at other times the work was carried out individually although resources, such as coloured pencils, glue sticks, and scissors, were still shared. The table, at Figure 4.06, summarises the range of activities

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\(^6\) Laptops and tablets were shared resources in the school brought into the classroom when they were required.
observed in the classroom during the course of study, the respective modes of working and whether during the activity pupils were mostly sitting on the floor or at a table.

<table>
<thead>
<tr>
<th>Working Mode Activity</th>
<th>Whole class</th>
<th>Group</th>
<th>Pairs</th>
<th>Individual</th>
<th>Floor-based</th>
<th>Table-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal Reading</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Informal Reading</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Writing</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maths</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutting &amp; Sticking</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Painting</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawing</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>IT-PC</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>IT- Laptop or Tablet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Listening</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussing</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Show-and-tell</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Changing for PE</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Music</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watching media</td>
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<td></td>
<td>x</td>
</tr>
<tr>
<td>Registration</td>
<td>x</td>
<td></td>
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<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

Figure 4.06 Table showing observed activities and modes of working.

Between the first and second years of the research the class teacher changed and so, to some extent, the content and character of the room also changed. Figure 4.07 illustrates how the classroom furniture was reconfigured during the three-year timeframe of the research.

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66 Music lessons occasionally took place in the classroom but were mainly in a separate music room or in one of two assembly halls.
Figure 4.07. Classroom floor plan over three academic years
Although there had been a change of class teacher the daily classroom activities followed a similar format. For the most part, school days began and ended with the whole class sitting on the carpet looking towards the teacher at front of the class. The remainder of the day was interspersed with movement between sitting on the floor and sitting at the tables.

Beyond the classroom the school had two large assembly halls and two playgrounds and the nursery had a small playground for its exclusive use. Break times were generally spent outside in a playground and lunch was eaten in the dining room. PE was either in a hall or a playground. Music had its own designated room but on occasions a music teacher would use a classroom or one of the assembly halls. Afternoon assemblies and concert rehearsals were in the hall, usually with children from other year groups. Occasionally, a parallel class came together in one classroom and children would have to shuffle closer to each other on the carpet to make space for an additional thirty small people.

In the classroom the activities that pupils were engaged in could be very broadly divided into two, listening or doing. Throughout the day children might be called from the classroom for individual or group activities elsewhere. On and off, pupils would leave momentarily to use the toilet or to wash glue, or paint or clay off their hands. Mornings had a more formal, organised structure, afternoons less so. When children had finished their work, or had unstructured time, they were able to use and explore resources such as the book corner, the “shop”, or one of two computers. Occasionally there were topical additions to the classroom such as a tank of tadpoles or an incubator with hatching chicks to study. A classroom is a dynamic space hosting a large number of different activities but there is also movement within and across the whole school. However, at times pupils were required to be more static.

From a furniture design perspective the fact that pupils spent time sitting on the floor was of interest. Photographs were taken showing rows of pupils sitting cross-legged and sometimes shuffling about. “Show me your
good sitting children” was occasionally heard when the children’s collective attention was required, for example, when classes gathered for an assembly. This phrase was rarely used in the classroom at the centre of the study; however, Figure 4.08 shows an image from a display board in the parallel classroom and it illustrates this concept of good sitting. Cross-legged, hands in laps and all looking attentively in the same direction. Figure 4.09 shows a participant, in an everyday classroom situation, demonstrating good sitting67. Although it was not enforced too rigidly when children adopted this posture it appeared to indicate that they were paying attention.

Figure 4.08 Good sitting in theory and… Figure 4.09 …in practice
Source: the author, original in colour

Sitting cross-legged and unsupported for any length of time, as discussed in Chapter 2, is biomechanically particularly challenging. Figure 4.10 shows a boy, Finn, sitting cross-legged on the carpet an excessive outward lumbar curvature is evident in his lower back. From this point of view good sitting shares common characteristics with right-angle sitting in that it is not conducive to maintaining natural spinal curvature; it is likely to be uncomfortable over time. Other pupils, boys in particular, seemed to

67 The origin of the concept of good sitting, investigated further during an interview with a lecturer of primary school student teachers, is thought to be from the 1990s. Asking, or telling children to sit properly was seen to be a vague request so good sitting had particular attributes that could be described as crossed legs, hands in lap, sitting up straight. Also, good looking (looking at the teacher) and good listening complimented this.
find sitting still on the carpet a challenge and they adopted variations of
the cross-legged position. Part of the same sequence as Figure 4.10
Figures 4.11 and 4.12 show Finn, after some time, sitting on his hands,
then on his feet while his legs remain crossed. It is possible that this could
be an attempt by children to raise their hips above their knees and relieve
lower-back pressure, or simply children trying to be more comfortable.
Finn’s back is noticeably more upright in Figure 4.12 when his hips are
slightly above his knees.

As a result of this observation the potential to introduce a design
intervention was considered. This would have involved testing the
outcomes of providing pupils with a means of sitting more naturally and it
would have entailed whole class participation. However, despite having
the deputy head teacher’s and the class teacher’s approval, and interest,
there was insufficient time for this additional study to be carried out within
ethical guidelines. Therefore the research continued with the focus, once
again, on classroom chairs.

The research progressed with reference to the data on modes of teaching
and whether activities were floor or table (and chair) based. In a passing
conversation Tania pointed out that pupils sitting at the tables had,
sometimes irresistible, distractions right in front of them that could prevent
them from paying full attention to what she had to say. In an interview she remarked on the benefit of having the class sitting on the carpet in front of her:

Tania “…it’s so easy sometimes to keep them on the carpet, because that’s the best way of me talking to them.”

This underlined the researcher’s observation that when sitting on the floor, in the classroom, pupils were mostly expected to be listening, or watching. By contrast sitting at a table was when, as reported by a participant in section 4.8, below “you can do something”. The literature review, in section 2.2, revealed that listening and doing are two different kinds of classroom activity, needing different types of physical support, and that the traditional design of UK school chairs represents a compromise between the two (Knight and Noyes, 1999). They are unlikely to be supporting either activity well. This is a variation on Dewey’s observation, in 1899, that the school chairs of the day were designed for listening and not for doing (Dewey, 2008). This study has revealed a behavioural expectation in that when children are sitting on the floor good sitting can be equated with good listening. This then leaves the question: what should good sitting look like when pupils are not listening but doing; when they are actively engaged in a task sitting on a chair at a table? It is clear that the primary school chair’s key function is to support table-based activity. It is a chair to support doing, a task chair. The design of a classroom chair should reflect this.

Having observed the teacher’s role in structuring what classroom activities required furniture, when and for how long, emphasised her role as a secondary user of the furniture. This required that her views be explored in more detail. Tania Cooper, who was the class teacher over two academic years, agreed to take part in the research.
4.3 Establishing teachers’ needs: part 1
Tania participated in a cultural probe style investigation exploring the sub-question: "what do teachers need from school furniture?" A photographic project was set. She was asked to take pictures of classroom scenarios in which the furniture was assisting in her delivery of lessons and otherwise. She used her own camera phone for this purpose and brought a set of prints to discuss at a later meeting. This phase of research took place in the final term of the 2014 school year. The images presented are a combination of Tania’s and of the researcher’s.

At the meeting to discuss the meaning of the images captured by her photographs Tania’s first remarks related directly to the question on what teachers need from the furniture:

Tania. “What I really need from the furniture is a space where children will sit, they will do their work and they’ll be able to access their work. They’ll be able to talk with their partner when it’s appropriate and… they’ll be comfortable enough to sit there for, I would say I’d be happy with them sitting down for twenty minutes in year one. Twenty minutes bordering on half an hour, an hour…”

She went on to add that the pupils:

“… need to be able to write and writing is really important. Doing their maths is mostly, not all the time, but mostly it’s done at tables which means that they need to write… you need something to rest your book on.”

The need for a space beside a partner (a mode of working), and a means of support for pupils to be able to work, in comfort, over a period of time, was clearly stated at the onset. These were expanded on and reinforced through further discussion supported by the photographs that Tania presented.

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68 Some photographs that Tania took were of non-participant children. These images were included in discussions but have been substituted in the thesis for similar scenarios from the researcher’s ethically managed collection.
English and Mathematics are core elements of the national curriculum, taught daily at all Local Authority Maintained schools in England (National Curriculum, 2013). As a daily routine, in a system established by the school, English lessons were taught first thing each morning, followed by Mathematics. Figure 4.13 shows how Tania arranged workbooks for English and Mathematics lessons on the tables before children had arrived each morning. English lessons included mixed age groups of children from Year One to Year Four (a potential age range of five to nine years old). The implications of this for the research are mainly anthropometric as there is a possibility that during the first hour of each day a nine year old child might have to use a chair designed for a five or six year old, and vice versa.

![Figure 4.13 Morning table setting](image)

Tania arranged the English books on the table adjacent to the pupils’ designated partners. The next lesson’s books, for Mathematics, were available in the middle of the table. Her ideal was for chairs to be arranged around three sides of the table leaving one side open for children to see her at the front of the class, a very neat, tidy and static configuration. In the next photograph, figure 4.14, Tania described a scenario when the tables and chairs were fulfilling her requirements.

*Tania.* "... they [the pupils] were working, doing what I had expected them to do here, and I would say it was successful in terms of my outcomes. I
wanted them to do the writing, they all had space to use an A3 piece of paper and do writing on it and they were all very calm and... they didn't distract each other, [and] they weren't on top of each other.”

Figure 4.14 Children working as expected
Source: the class teacher, original in colour

Teachers plan their lessons around expected outcomes or learning intentions in line with the national curriculum. In this case Tania’s predicted outcome was that the children would work on a particular piece of writing individually, without disturbing each other:

Tania. “…at that stage in the year I wanted them to sit and write on their own without talking for twenty minutes.”

This indicates that school furniture needs to be multifunctional, in that it needs to support pupils working in pairs and individually. There needs to be flexibility in the design in order to support different modes of working.

The conversation moved on from Tania’s explicit furniture needs and turned towards her expectations of how, behaviourally, the children ought to use the furniture and how, sometimes, such hopes were not realised. It is through discussing the following images that the teachers more implicit needs began to be uncovered. She commented on two photographs (figures 4.15 and 4.16) of children sitting on the edge of their seats:
Tania. “...that’s [a] quite commonplace way for them to sit like that, with the chair at an angle [because] they’ve pushed it back and just leant forward.”

Tania. “This [Figure 4.16] annoys me [particularly] the fact that the chair’s not tucked into the table because it’s a safety hazard for the other children and he’s [the child photographed] likely to fall off his chair which actually they do quite a lot... Therefore that chair becomes like a safety hazard because he’s not sitting on it [as expected], he’s sitting on it comfortably.”

Similarly, an observation noted in the reflective journal stated:

“Children working at the tables [on a] painting tend to sit forward on the seats, perching at the front or on a corner.”

Of the nine images that Tania presented two were of children perched on the edge of their seats or, in school vocabulary, “not tucked into the table”. Tania finds this problematic and she goes as far as to say this “annoys” her and causes a “safety hazard”. However, Tania also recognises that, although children are not sitting on the chairs as she would expect, the children are comfortable. There is a discrepancy revealed here between Tania’s expectations of the way pupils should sit (for their own safety) and the need that she expressed earlier for children to be comfortable when they are working. Why would a benign looking school chair become a hazard? Is it bad design - or something else?
School chairs become hazards for a number of reasons. Children might fall off a chair if they tip it too far backwards, or forwards, on two legs.\textsuperscript{69} Chapter 2 described the Max II chair designed to stop children from tipping their seats\textsuperscript{70}. More often children accidentally slide off the front, or miss it entirely, when going to sit. The photographs below, Figures 4.17 to 4.19, Illustrate a common scenario in the classroom; a boy sitting on his chair, and then standing to reach something on the table. As he stands, the back of his legs straighten and in doing so push the chair backwards. When he sits down again he is perching on the front. On occasions children miss the seat, thereby causing a fall.

![Figure 4.17 Sit](image1) ![Figure 4.18 Stand](image2) ![Figure 4.19 Perch](image3)  
Source: the author, originals in colour.

However, Tania also recognised that sometimes perching on the front is a more comfortable way to sit. A participant in the pilot study, Lily, knew and could articulate clearly why that was the case for her. She approached the researcher twice in the classroom to discuss a feature of the school chair that she found particularly uncomfortable.

An excerpt from the research journal (17.07.13) notes:

\textsuperscript{69} Appendix 05 contains a compilation of photographs taken throughout the research of children tilting their chairs towards their work.  
\textsuperscript{70} MERU (who make specialist products for disabled children) offer a device to attach to conventional school chair legs to prevent this.
“Lily showed me (unprompted) that it is the shape at the back of her seat (lumbar support) that presses on her back and is uncomfortable. She tells me that she has to lean forward to stay comfortable.” (Figure 4.20)

![Figure 4.20](image)

Lily on the front of her seat  
Source: the author

This can be related to the literature on seated posture and the question on whether or not children’s chairs need to provide lumbar support. The shape of a spine is highly individual and children’s spines are still developing. Using the hard form of a chair back to push a child’s lumbar spine into a predefined shape is likely to cause discomfort because it is not their natural shape. This presents a biomechanical argument for finding a more natural way of supporting pupils’ seated postures that should have a positive impact on their comfort.

Throughout the school day the class ebbs and flows from sitting on the carpet to sitting at tables and back again. The class teacher needs to be able to circulate around the room freely to tend to her pupils. The ability to circulate around the space is important but chairs can become troublesome by getting in the way, and that they are noisy to move.71

Tania. “I know that in that lesson, it was [an] English lesson, I found it really difficult to get through that area...because [a particular boy] was sitting on it like this...”

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71 Noted also by Bond et al (2002).
Tania demonstrated by perching on the front of her seat. As seen above in the sit, stand, perch scenario, when pupils stand, the seat is often pushed backwards by the action of their legs straightening. Chair legs can knit together causing a tangle, thereby blocking access between tables (Figures 4.21 and 4.22).

If, by moving around, children cause seats to get in the way or to become hazards, what measures can a teacher take to resolve this? One way of keeping unruly chairs under control is to ask the children to tuck them in. I had observed the previous class teacher instruct pupils to do this when they left a table. This could solve the problem of obstructive chairs in this instance but what about when pupils are working at tables and also need to be comfortable?

Tania “…They know what I expect of them… I haven’t really enforced tucking in the chairs so when I need to move through I tell them to tuck in their chair but I think I probably should have enforced that.”

One of the first needs that Tania defined was for space for pupils to do their work. This can be interpreted in two ways: 1) a space to sit, lay out work and access resources, and 2) the environmental space for children to work in and move through, and for the teacher and those helping in the classroom, to be able to circulate. The classroom in the study had been extended to incorporate half of the space from an adjacent room.
Relatively speaking, this classroom was bigger than most in the school. However, the available space still appeared to be tight, possibly due to the size and shape, and the arrangement of tables. The floorplan can be seen at Figure 4.07 above and show that despite trying different layouts there were always pinch points in the circulation spaces between tables. This was particular noticeable when children were sitting at the tables.

The spatial arrangement of this particular classroom is the result of an evolutionary design. The school was a Victorian building constructed to hold Victorian rows of desks. The classroom may have been extended to accommodate the more flexible open plan teaching style discussed in section 2.4. At the time of the research the furniture arrangement was to suit something between the two styles, where the pupils moved from the carpet in front of the interactive white board, to the tables and back again. A question arises: in procuring furniture for the space was any consideration given to the current pedagogical style? This opened up a new line of enquiry for the research to pursue with those involved in procurement in the school and it will be discussed in more detail in the next chapter.

From a classroom management point of view it is clear that the teacher wanted chairs to be tucked in, although she did not always enforce it. However, the idea that school chairs should be tucked in at all times was reinforced by a visiting occupational therapist. This prompted opinions that merited further investigation:

JL. “... you mentioned that the OT said what she thought was the best way for them [the pupils] to be sitting when they are writing.”

Tania. “Yes... their back needs to be against the chair [back] and their feet need to be flat on the floor… the chair, tucked in.”

The occupational therapist’s impact on the classroom environment comes in two forms. Professionally she offers an opinion rooted partly in biomechanics. However, as an external professional she also has authority that is outside the realm of the teacher’s expertise. Combined,
these mean the effect of her opinion is assumed to be unquestionable by the teacher. If the chairs are tucked in, it is good on two counts; the chairs will be out of the way and the children are sitting properly. What is not known is the impact of such a prescribed way of sitting on pupils, particularly in the light of revelations from the literature on conflicting thoughts on good-seated posture. This line of inquiry was explored with participant pupils in a classroom study discussed later in Section 4.9.

Summary of key points

The sub-question, for this part of the enquiry, set out to investigate what teachers require from school furniture. The explicit needs were defined as the provision of physical support for pupils working on particular tasks, flexibility to accommodate different modes of working and that children are comfortable to work on tasks over a period of time. These can be summarised as ergonomic requirements and almost equate to Pheasant and Haslegrave’s (2006) functional requirements of a comfortable chair, discussed in Chapter 2, that a chair should:

“… provide stable bodily support that is: comfortable over a period of time… [and] appropriate to the task or activity in question” (p.121).

However, and paradoxically, the ways in which pupils use the chairs causes problems in the classroom. Tania’s implicit needs were about modifying pupils’ behaviour to meet certain expectations. For example by not sitting properly, and in a way that was reinforced by the occupational therapist, children are not conforming to the teacher’s expectations and chairs become hazardous and “annoying”.

As with the historical associations of sitting, seen in Chapter 2, seated posture in school is affected greatly by expectations from social systems, in this case the school’s. Pedagogical needs are to the fore. Critically, the children’s comfort is seen as important but the teacher has no firm understanding of how that is best achieved. The teacher is reliant on another professional’s knowledge in this respect.
Key areas for two further investigations were identified. Questions were raised about 1) the school’s criteria for buying furniture and 2) about the impact on pupils of adopting the occupational therapist’s prescribed way of sitting. These lines of inquiry were pursued and the findings will be discussed later.

4.4 Establishing teacher’s needs: part 2
A second meeting was arranged with the class teacher, Tania, to broaden the exploration of pedagogical matters by sharing initial findings from the research. This discussion took place early in the following academic year. In the intervening months photographs, passages of dialogue from interviews, and reflections on the research had been collated into a large sketchbook. This served as an information repository and was used as a focal point for this discussion.

Reading is a fundamental activity in a primary school and children were observed reading in pairs during morning English lessons as well as in their own free time in the afternoons. Collaborative modes of working were a common occurrence in the classroom.

The researcher photographed two pupils (Figure 4.23) sharing a reading book during a morning English lesson. This was a formal session and children are expected to sit beside their partner sharing a book and taking turns to read whilst their partner points at the words with a wooden pointer.72

72 This device looks like an ice-lolly stick.
This takes some degree of cooperation. However, during a number of these sessions disputes were observed between the two pupils featured in the photograph. Occasionally one child might not have been in the mood to share but, even setting this aside, the school furniture seemed to conspire against a collaborative spirit. The book was often pushed and pulled between the pupils as they competed to see or to point at the text. The width of the chairs made it hard for both of them to get close enough to share the book and the position of the table legs made it impossible for them to shuffle any closer. The wide format of the book did not help matters either. Children need a relatively short distance to be able to focus on a piece of work (Mandal, 1984). This is a particularly important point to be considered from a pedagogical point of view but also in terms of furniture design.

In contrast, during less formal afternoons sessions children were observed reading in pairs of their own accord. The book corner, well stocked with factual and fictional books, had beanbags where children could snuggle up close and share a book together (Figures 4.24 and 4.25). Although the children are semi recumbent their postures form an open angle between the trunk and thighs.
Tania discussed the close proximity of children collaborating on a piece of work (Figure 4.26).

Tania “…they were working together and they were both writing on a shared piece of paper. And they were doing lots of talking… but I thought it was quite interesting the way they were sort of turned quite close together… We’re instructed in the school to say “turn to your partner” and… their bodies should still be facing forward, their head should just be turning to face them [their partner]...”

The school system’s expectation of how pupils ought to collaborate seems unrealistic. When pupils share resources like books or laptops they need to be able to get (and don’t mind being) close enough together for both to
access the work. If their natural inclination is to be close to a partner, and it helps to meet the teacher’s needs, then school furniture should be designed to enable rather than discourage this.

Out of nine of Tania’s photographs six showed children that were not sitting as she expected them to. As seen earlier, some were perched on the front of their seats; others knelt beside, or leant against the table. (Figures 4.27 and 4.28) Despite these non-conformist postures it is most important to note, that pupils remained engaged in the required activity, working on a task but just not sitting properly.

Tania acknowledged this when commenting on a boy who, having slipped off his chair, was seen to be working at a table whilst kneeling on the floor; like the girl in Figure 4.27.

Tania. “...he obviously realised that he’d slipped off but was really focused on what he was doing so potentially... it didn’t really matter.”

A final question put to Tania asked what improvements she thought could be made to school furniture.

Tania. “I just can’t think of a way that you can get children to be more comfortable when they are sitting at a table doing writing... We, as a school, wouldn’t let children just wander around and choose where they wanted to do something because part of it is getting them into a behaviour
routine that they can continue on, and I think it’s a bit stifling from time to time... It starts [in] year one because in reception... they sit at tables when they’re doing activities with teachers... and they don’t do it for very long at all... but they need to learn now that they write at tables for a certain period of time. They don’t get up and wander around.”

Her response does not offer tangible suggestions and she is resigned to accepting that pupils might be uncomfortable whilst working at school. The behavioural expectation of sitting down to work emanates from the school system and is instilled from an early age.

However, her participation in the research had caused her to reflect on her teaching style⁷³ and her comment below prompted the investigation to look beyond the classroom environment at what could have influenced this. Tania had recently qualified as a teacher and it was clear that her training had not included ways in which the classroom furniture could be used as a resource or, as an educational tool.

Tania. “So I think, it made me think about, because I just came into teaching and obviously this is how I was taught, …so I hadn’t really thought about the fact the furniture… The only thing I thought about this class is that I’d like smaller tables…”

In response to Tania’s comment indicating a lack of training the research widened to include interviews with two university lecturers involved in teacher training. This is discussed in more detail later in section 5.4.

Summary of key points
Children sitting in less than conventional ways are seen to be working. However, there is a tension between this kind of behaviour and the teacher’s expectations. The school system seems to hold assumptions with regard to how children should sit when they are learning. It is not within the scope of this research to investigate the effects of posture on learning. Nevertheless, this phase of the research suggests that children

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⁷³ This was consistent with literature (Pointon and Kershner, 2000) previously discussed in section 3.1.
do not have to be sitting in a prescribed way to be getting on with a
designated task.

Children’s natural inclination, or lack of aversion, to getting close to their
partners is helpful when sharing resources. The implication for design is
that chairs should support children’s natural inclinations to achieve comfort
and ways of working. However, these natural inclinations appear
compromised by the school’s behavioural expectations. In short, the
school’s expectations of children’s postural behaviours could be getting in
the way of children doing the work.

4.5 Pupil participation
The sub-question on ascertaining pupils’ needs from classroom furniture
was pursued with pupils actively participating in five different studies.
Different methodological approaches were employed to determine the best
means of gaining pupils’ insights in a working school situation whilst
causinng the least interruption to their education. Methods were modified
or changed according to the success, or otherwise, of the preceding
iteration.

Findings from the pedagogical perspective, presented in sections 4.3 and
4.4, have raised a critical point with implications for school pupils.
Children’s comfort is clearly a key factor from ergonomic and teachers’
perspectives but comfort is intrinsically linked to, and could be
detrimentally affected by, teachers behavioural expectations. The studies
described below aimed to understand the experiences of using school
chairs from a pupils’ perspective, to examine what properties affected their
comfort and to consider how this could be improved by design. A
prototype, based on an existing design, was tested with participants in a
classroom to evaluate, the effects of sitting in a non-conventional way:
sitting astride rather than on the seat. Also, to investigate whether
children of different heights could comfortably use the same chair if sitting
in this less conventional way.
At the end of each section where pupils have been participants there is a reflection on the methodology used in the study. These explain the decisions that were taken that affected subsequent iterations of the research. They are written in the first person and for clarity are distinguishable by appearing in grey coloured text boxes.

A synopsis of the pilot study is presented below. This consists of the key objectives and findings. It includes a discussion of the findings and resulting methodological changes, the implications in the findings for school furniture (chair) design and a personal reflection on the methodology.

Although studies are presented in a sequence they were not carried out in exactly that order. Some, for example the anthropometric study, consist of data collated from different cohorts of participants. Each section contains information on participants; a description of the procedures and equipment used and concludes with a summary of key points and a personal reflection on the methodology.

4.6 Pilot Study Synopsis

The main objective of the pilot study phase was to test and evaluate research processes and data collection methods that might be used with child participants. Carrying out the pilot study provided the researcher with an opportunity to learn from the experience of researching in a working school environment and to consider meaningful ways of engaging young children in the research process. Relevant visual material illustrating postures and anthropometric data arising from the pilot study was incorporated into the overall research database.

Eighteen participants were recruited from the class of twenty-nine. Four methods were used, a short questionnaire, anthropometric data collection, observation and a reflective journal. Data gathered was:
• Textual data - Notes on observations of children’s postures and school activities. Also, a compilation of words and things that children equate with feeling comfortable, gathered through a series of group discussions presented in a table below, Figure 4.29;
• Visual data - Drawings and photographs of children sitting at school on the floor and on the chairs for postural evaluation;
• Anthropometric data - Related to furniture design requirements and incorporated in the study detailed in section 4.7 below.

<table>
<thead>
<tr>
<th>Group</th>
<th>Comfortable meaning</th>
<th>Examples of comfortable things</th>
<th>Examples of uncomfortable things</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fits</td>
<td>Sofa</td>
<td>Tight</td>
<td>1,2,3,4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pyjamas</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pillow</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Slippers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Onesies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Place you like to be</td>
<td>Pillows on a couch</td>
<td>Too hot</td>
<td>5,6,7,8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cool to touch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Happy to do it</td>
<td>Book corner</td>
<td>Hard wood</td>
<td>9,10,11,12,13</td>
</tr>
<tr>
<td></td>
<td>Soft and furry</td>
<td>Soft trousers</td>
<td>Itchy jumper</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fit</td>
<td>Bed sheets</td>
<td>Spikey, hairy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Doesn’t make</td>
<td>Slippers on a cold night</td>
<td>pants</td>
<td></td>
</tr>
<tr>
<td></td>
<td>you tired</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>You are very</td>
<td>Bed</td>
<td>Sharp spikes</td>
<td>14,16,17,19</td>
</tr>
<tr>
<td></td>
<td>cozy</td>
<td>In clothes</td>
<td>Wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soft and smooth</td>
<td>Car seat</td>
<td>Plastic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soft cushion</td>
<td>Pillows</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>means you</td>
<td>School chair</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>don’t wiggle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>about</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feeling nice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Nice to sit on</td>
<td>Sitting on your bed</td>
<td>Uncomfortable</td>
<td>18 + 2</td>
</tr>
<tr>
<td></td>
<td>Feels nice</td>
<td>Something soft</td>
<td>Spikey grass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nice to wear</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.29 Table of words and things children associated with comfort
Figure 4.30 below is a series of images of Freya sitting on the carpet. The sequence of fourteen postures was taken over approximately five minutes equating to a significant movement approximately every twenty seconds.

Figure 4.30 Freya sitting on the carpet over five minutes
Source: the author, originals in colour

Photographs of children working on school tasks show that they adopt a range of different postures. In Figures 4.31 to 4.34, whist writing and
drawing, Louise was observed to be perching, twisting, sitting mid-seat and kneeling on her chair. Jacob, in Figures 4.35 to 4.38, was observed perching, sitting mid-seat, standing and twisting and standing with a flexed trunk. In these photographs although the children may not be sitting as a teacher would have expected they are engaged in the activity in hand.

Discussion of findings and methodological implications
At the onset the research project was to have taken a user centred approach concentrating on the pupil chair relationship. During this first phase, time spent observing in the school classroom highlighted the teacher's central role in determining pupil’s movements and activities. Consequently, the pupil-teacher relationship assumed equal importance to
that of the pupil-chair interface prompting the inclusion of a class teacher into the research following the pilot study.

An evaluation of the pilot study’s administrative processes also prompted alterations for subsequent iterations of research. Questionnaire and anthropometric data collection had taken place, with groups of four or five participants, in an adjacent space to the usual classroom (Figure 4.39). Two issues were raised. First, the room was furnished with slightly different tables and chairs, meaning children had to rely on their memory of the classroom furniture when responding to questions about it. Second, the researcher was wholly responsible for the group and the process; gathering anthropometric data needed the researcher to focus attention on one individual child. Balancing the demands of accurate measuring and recording with keeping the remaining participants safely occupied was a challenge. As a result the remaining studies took place in the children’s usual classroom. Also, in response to this first phase the parental consent form was re-designed to make it easier to complete and to make consenting more explicit.

Methodologically, visual data generated in drawings and photographs was judged to be a successful means of capturing data on postures and the nature of tasks and so these methods were continued. That the children spent lengthy stretches of time sitting on a carpeted area, rather than on
chairs at tables, was surprising and particularly intriguing for a furniture design project. The images of Freya shifting about the floor (Figure 4.30 above) were at odds with the request that children were to sit cross-legged in this situation. As previously discussed in section 2.1, ergonomically, this is a hard posture to maintain for long without support. Some pupils slumped forwards quite quickly loosing their natural lumbar curvature. In addition, because the whiteboard was positioned on the wall at around the teacher’s standing height, children had to look up to be able to see it. The combination of slumping forwards whilst having to look up makes an awkward and uncomfortable posture. There was some respite when the pupils had been sitting for too long or, when they collectively became quite wriggly the teacher would ask them to stand up and have a stretch. There were rhymes and games to accompany these moments.

The participants’ group discussion on comfort was designed as an introduction to the questionnaire. However, the children appeared to enjoy the discussion and the results gave an indication of children’s concept of comfort in the words and things that they associated with this notion (Figure 4.29 above). Therefore this line of enquiry was continued in subsequent studies, although it was carried out with individuals rather than groups. The participants had enjoyed completing the questionnaire but the over-all results proved inconclusive so a means of eliciting pupils’ thoughts on the experience of sitting at school was required for the next phase of the study.

The reflective journal was a useful resource for recording and storing different aspects such as details of research processes, checklists and timings. It also provided a means of recording important conversations in-passing that could confirm the findings of the literature or otherwise. Its use was continued. Events were recorded as they unfolded in the school and later on reflection.
Key points
The pilot study found that space planning in classrooms was an issue and this was compounded by the chair design; resulting in chair legs tangling causing obstructions in the room, as highlighted in section 4.3 above. Space efficiency and the type of leg support therefore, were identified as features for design consideration.

A particularly significant moment in the pilot study (discussed previously in section 4.4) was when a participant mentioned, in passing, that she found the chairs uncomfortable. She indicated the lumbar curve in her seat as the cause of the discomfort. This, and the literature finding on children’s lumbar curve developing around puberty (Lueder and Rice, 2008, p.195), brings into question the type of spinal support that children need. Therefore, the form of and purpose of a backrest needs further investigation.

Reflection on methodology
Reflecting on the questionnaire and anthropometric data collection procedures I realised that I had unwittingly re-created a familiar instructional/pedagogical styled of an adult standing beside a board in front of a group of participants who were sitting behind desks. There were a number of potential factors that could have influenced this. I had been helping in the classroom for a number of weeks and it would have been difficult not to be swayed (to some extent) by the classroom pedagogy, although the teacher did not have a particularly formal style.

More likely it occurred because of the arrangement of furniture in the
room in which the study took place. Also, there was a keenly felt and significant pressure to get each group though a number of tasks concurrently, within a reasonable timeframe, whilst keeping the participants interest.

The first task was for them to complete a questionnaire and this required prior explanation and a short discussion. I had moved the furniture so that the children could see what was written on the whiteboard. The room and my resources were arranged for me to maximise control; and to minimise distractions I kept all the questionnaire materials beside me to be handed when needed.

Anthropometric data collection was particularly challenging. Most groups consisted of four participants and when it came to taking measurements I opted to give two a desk-based activity whilst measuring the other pair. As only one pupil could be measured at a time the other was free to stand and watch or to find an alternative and occasionally risky activity. Climbing on stacks of chairs was a favourite. I was aware that I did not have the same authority as a teacher, and so were the children. Children’s safety (and educational) needs were paramount so I was inevitably distracted from the research from time to time. This prolonged the procedure as I double-checked the measurements in case of errors.

4.7 Anthropometric data: is the seat height correct?
Popliteal height was identified in Chapter 2 as the standard means to determine the correct height of a seat. In this study the participants’ popliteal heights were measured for comparison against the actual seat height of the school chairs they were using and against the British Standard (BSI, 2007) recommended seat heights. The sizes are
coded in the British Standard enabling easy recognition of corresponding table and chair sizes.

Participants
The participants were recruited from two year one classes, in different academic years, in July 2013 and July 2014. The pupils were aged five or six years old and occupied the same classroom furnished with BS compliant, Size Mark 2, chairs and tables. Children who had the prior consent of a parent or carer were invited to participate in the research and to give their own informed assent before data collection began. Class A had a total of 18 participants and Class B a total of 20.

The procedure used to gather popliteal height data was the same as described above in section 3.2. Data was then transferred to an Excel spreadsheet to generate graphs detailing the relationship between a participant’s popliteal height and the heights of seats designated in the British Standard (BSI, 2007 and 2015). In line with procedure detailed in the British Standard, a 25mm shoe height allowance was added to the popliteal heights data. (BSI, 2007, p.28) Findings are set out in below in Figures 4.52 and 4.53. Raw data can be found in appendix 06.
Findings

Figure 4.40 Distribution of popliteal heights against standard size marks
Participant Class A 2013

![Graph showing distribution of popliteal heights for Class A participants from 2013, comparing different chair heights Against BS1729:1:2015 size guidelines.]

Figure 4.41 Distribution of popliteal heights against standard size marks
Participant Class B 2014

![Graph showing distribution of popliteal heights for Class B participants from 2014, comparing different chair heights Against BS1729:1:2015 size guidelines.]

Discussion

The graphs above (Figures 4.40 and 4.41) show the distribution of Class A and Class B participants’ popliteal heights set against BS1729 (BSI, 2007).
and 2015) recommended seat heights for chair size marks 1, 2, 3 and 4. Solid horizontal lines represent the size mark chair heights. The participants were using chairs compliant with size mark 2 (represented by a purple line) in their normal classroom. As discussed in the literature review, in section 2.4, pupils’ popliteal heights should be greater than the seat height that they are using to avoid experiencing undue pressure on the back of the leg (BSI, 2015, p.60). A seat height that is too high can cause the thigh torso angle to decrease causing pupils to slouch (BSI, 2015, p.60). Both situations would have potentially detrimental consequences for pupils’ short-term and long-term postural health.

When compared to the chair size mark 2 seat height (Figure 4.40) the graph shows that all pupils in class A, bar one, had a popliteal length greater than the seat height that they are using. One pupil, A6, had a popliteal height equal to the seat height indicating that a lower seat height might have been required. Participant A5 is 5mm above the size mark 2 seat height, raising a question about whether he/she should also have been provided with a smaller chair. Furthermore when comparing the participants to the other size mark seat heights it is evident that one child would have fitted a size mark 4 chair and five pupils a size mark 3.

In comparing class B pupils against the mark 2 seat height two participants, B14 and B18, were below the seat height that they were using, indicating that a size 1 chair would have been a better fit in this respect. Participant B11 had a popliteal height 5mm above the size mark 2 seat height like A5 above, this raises a question about whether he/she should have been provided with a smaller chair. Four class B pupils would have fitted size mark 3 chairs.

Key Points
The study consisted of a relatively small sample yet the results illustrate the degree of variation in children’s popliteal sizes appearing within a standard school year group. These findings suggest that in order to accommodate all the participants, according to the popliteal height
parameters set out in the standard, a classroom would need to have up to four different sizes of chairs available. This is an indication of the degree of difficulty in designing a conventional type of chair to accommodate comfortably the wide variety of pupil sizes in any one-year group sharing a common classroom. For a school to provide a wide enough variety of sizes is not practical; how would children know which size to use, what if there were not enough of the right size and where would excess chairs be kept?

Continuing to select and to provide school chairs on a one-size-fits-all basis means that some pupil’s biomechanical requirements, and therefore comfort, will always be compromised. There is also the potential impact on children’s physical health. Those pupils whose lower leg length is shorter than the seat height may have difficulty putting their feet flat on the floor. This is likely to cause discomfort and difficulty in finding a comfortable and stable position to hold for any length of time. At the other extreme, those children whose popliteal height is significantly greater than the seat height may compromise their lower back. The combination of the length of their lower leg and the rearwards rake of the chair’s seat pan could cause them to assume awkward postures.

Class B participants also took part in informal interviews to gather insights on their experiences of sitting in the classroom on a size mark 2 chair. It is notable that two participants B11 and B17, with popliteal heights 5mm and 10mm respectively above the actual seat height independently remarked that the front edge of their chair catches on the back of their legs. B20, who was also 10mm above the seat height, did not pass a comment. However, this emphasises the importance of asking children’s opinion on products that they are expected to use. Summer uniforms - shorts and summer dresses - leave children with bare legs and little protection

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74 Although the British Standard accommodates for seats sloping between -5 and +7, i.e. sloping forwards or backwards conventional chairs, such as the type used in the classroom, are designed to slope backwards.
against hard edges of plastic seating. This is something that an adult might not notice or consider.

The smallest participant in Class B had particular needs and was supplied, by the school, with a wedge shaped cushion for seated support. Although on the graph there is some discrepancy between his popliteal height and that of the seat this did not prevent him from using the chairs.

Reflection on methodology  
At the start of the project, and in response to literature on school furniture dimensions, a wide selection of anthropometric data was gathered. These included measurements that would be used to calculate table heights.

Certain items of the FIRA equipment used for this purpose were cumbersome to use and I had questions on the accuracy of some of the data gathered in particular popliteal length and seated elbow height. When popliteal length, used to calculate the depth of a seat, was being measured the children had to sit upright whilst I moved the rig into position against their back. This did not take long and some pupils managed to sit in the required upright manner; others retained a curvature in the lower back that prevented the rig from reaching the correct position, therefore the points being measured were not consistent. When measuring the seated elbow height, to determine table height, the children were again asked to sit upright. However, as soon as I moved the rig many children automatically lent towards the measuring device causing their elbow to drop.
As the project progressed the research concentrated more on the pupil-chair interface, consequently fewer measurements were required. For the final study exploring a different way of sitting in the classroom only pupil’s standing heights were measured.

4.8 Sitting at school part one: pupils’ preferences

The method for gaining insight from the pupil’s perspective was reviewed following the pilot study and in response a less formal method was devised. The research sub-question remained the same: “What do pupils need from classroom furniture?” The pilot study had gathered data that indicated certain words and things the children associate with comfort but had not identified more specific needs that could be used to design furniture for the classroom. Observation in the classroom revealed that children either sat on the floor or on chairs at tables. The pedagogical style was such that sitting on the floor was mainly for listening or watching. Whereas sitting at the tables was associated with activities like writing or reading. Both locations require a different type of support to suit the demands of the different tasks and the comfort of the children.

The next iteration of participatory research with pupils aimed to take a less formal approach. The researcher had noticed that children enjoyed making their own little books. This was an activity occasionally set by the teacher but one that children clearly enjoyed; when pupils had free time there was often a queue asking for help to assemble books by sticking or stapling paper together. Children of all capabilities could record their observations and thoughts in writing and or drawing. As a research method it had similarities to those used the Mosaic approach by being a reflexive process where listening, interpreting and making meaning are a combined activity (Clark and Moss, 2011). Book making was chosen as a method to facilitate a discussion between the pupils and the researcher to gain insight into their experience of sitting in the classroom. The aim of
the study was to elicit the children’s thoughts on the different places that they sit in the classroom and to hear their ideas on factors or features that make seating comfortable or otherwise.

Participants
This study was carried out with twenty participants, out of a class of twenty-eight pupils, in the last month of the 2014 summer term.

Procedure
The study took place in the classroom and whilst participants were using their usual chairs and tables. It was not uncommon for pupils to be engaged in different activities in the classroom, or to work with another adult and so when participants were available research activity was able to take place in parallel with other normal school tasks.

These interactions with the children were designed as informal interviews and each followed a similar path. Having been told what was required in the study the pupils were asked if they wanted to take part. With their agreement the ensuing discussion was recorded on an IPhone 5.

To keep the activity interesting for the children the researcher supplied sheets of A4 paper pre printed and ready to fold into books and a range of different coloured pencils.

Interviews followed a similar process. The opening discussion was on the project and different places that pupils sit in the classroom. This was carried out whilst the participant, with help from the researcher, folded their sheet of paper and cut along dotted lines to make their own book. The steps are illustrated below in Figure 4.2.

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75 Examples of participant’s books can be seen at appendix 07.
Then, whilst the pupils wrote or drew pictures, the discussion on sitting at school continued and included open questions to discover:

1) Where participants preferred to sit in the classroom and the reasons why?
2) Where participants didn’t like sitting in the classroom and the reasons why?
3) Any improvements that participants could suggest for the existing chairs?
4) Any other thoughts on what makes a comfortable place to sit?

Some pupils were happy to talk and draw at the same time; others worked quietly and talked in-between. The session ended either, when all the pages of the book were completed, or when the child’s attention waned. The resulting books were retained for a few days to be scanned and saved, before being returned to the original author. Interview transcriptions were studied and information detailing the children’s individual responses to the questions, outlined above, was transferred.
onto participant data sheets\textsuperscript{76}. Participant’s photographs were added to the same sheets to allow concurrent review of visual and textual data along with their height and popliteal height. The data was analysed, using thematic analysis, to identify different categories in response to the questions detailed above, e.g. where do you prefer to sit? Categories were then subdivided according to the reasons why. This process was repeated to identify themes or find patterns (Miles, et al, 2014) collating the individual’s thinking and interpreting the wider group’s thoughts.

Findings

Figure 4.43

Where participants preferred to sit in the classroom

Figure 4.43 illustrates the places that participants said they liked to sit in the classroom. The majority (15/20) chose a chair for a number of reasons. Most (9/15) stated postural reasons for preferring to sit on classroom chairs such as being able to stretch and move their legs and, or liking the support of a backrest.

\textsuperscript{76} An example of the participant data sheet can be found at appendix 08.
Two liked the height (Holly, had a specific reason which is discussed later), two had no specific reason and one simply liked the colour.

One pupil, Zoe, preferred to be at a table where “you can do something” because sitting on the carpet “you just have to listen to what you are going to do.” This reflects the researcher’s observations that were discussed previously in section 4.2, that, very broadly speaking, when sitting at tables pupils were engaged in an activity whereas when sitting on the floor they were watching and listening.

Three children liked to be in the book corner where there were “comfy” beanbags. Although one liked the space because it was quiet, another just loved reading.

Only one participant liked to sit on the carpet finding it “really comfortable because it’s soft.” However, this was not the consensus, as nine children didn’t like sitting on the carpet at all. Again there were a number of reasons: One pupils said the carpet was dirty and another found a lack of space meant that “you get squished”; three found the texture rough and three commented on not being able to move since “if you do it for too long it hurts your legs”. One participant reported that her shoelaces pressed uncomfortably into her ankles when she had to sit with her legs crossed.

Holly didn’t like the normal classroom chairs because they were too high. She and John chose the teaching assistant’s chair as their favourite seat because it was seen to be lower and had “more seat”, by being slightly wider. Their classroom chair seat was 310mm high and these children had popliteal heights below that, at 290mm and 295mm respectively. There were two other participants whose lower leg length was also less than the seat height but they did not comment on the comfort factor. However, Holly and John both said the front (waterfall-shaped) edge of the seat was uncomfortable on the back of their legs. This is a more important point than it might appear at first. Listening to the child’s view has revealed something that might otherwise not have been noticed. An adult
testing this kind of seat would be unlikely to have bare legs and so may not have felt the edge of the seat catching behind their knees. Children wearing school uniforms quite often have bare legs so their experience is different.

John also said that he liked to sit where he could rest his head and several photographs had captured him, and other children, doing that whilst working at a table (Figures 4.44 and 4.45).

When the participants were asked what could be done to improve the comfort of chairs the replies ranged from the practical, “make them height adjustable”, to the whimsical “loads of shelves, books, stars and moons and looking magical”. Suggested improvements were mainly related to tactility with requests to add “soft bits”, blankets, or “soft cushions”, or to provide “soft seats to jump on”, or simply “make it like a sofa”.

Millie (Figure 4.46) was photographed whilst busy writing over a duration of approximately 15 minutes. She is very absorbed in her work but unconsciously moving through a series of predominantly open-angle postures. The chair is seen tipped forward and sometimes she is barely sitting on it at all.
Figures 4.46 show Millie moving over approximately 15 minutes. Source: the author, originals in colour.

Figures 4.47 show Ted working at a table. Ted was one of the taller boys both in the participant group and in his class. He changed posture often and the difference in his spinal curvature between right-angle positions and open-angle ones is visible. Although his flexed postures indicated that the chair-table combination was not a good fit for him, Ted said that he preferred to sit on the chairs, because the floor was dirty.
Harry (Figures 4.48 to 4.50) liked to sit with his feet on the floor and his legs stretched out. He appears to fit the blue school chair in Figure 4.48 because he can get his back against the backrest and his feet flat on the floor. On the grey chair his thighs are parallel to the floor and this appears
to be a good fit for his popliteal height. In both chairs it seems likely that his lower back would be compromised if he was to lean towards his work.

![Figure 4.48](image1) ![Figure 4.49](image2) ![Figure 4.50](image3)

**Harry sitting in the classroom**

Source: the author, originals in colour

**Key Points**

Although the sample size was small the study has shown that young children can express views on school chairs that are useful and relevant for design purposes. Children have a point of view to offer that adults cannot predict or imagine. Their reasons for preferring chairs, such as being able to stretch out their legs and use backrest, indicate factors that can be incorporated into chair design as well as for further research.

Sitting on the floor was found to be the least popular place to sit and this is consistent with another study were children commented that sitting on the floor is not comfortable (Pointon and Kershner, 2000).

Pupils tilting their seat are a common occurrence in classrooms. This was highlighted in the literature review as being interpreted by teachers as low-level disruption.\(^{77}\) The images of Millie refute this idea by showing that she is still working whilst moving.

\(^{77}\) Appendix 04 has a compilation of photographs of pupils tilting their seats whilst they are engaged in table based activity.
When asked directly, children’s specific explicit recommendations to improve chairs were about the tactile experience of sitting. However, their more implicit postural preferences, space to move and stretch, and height, were revealed in conversations and through postural analysis. More importantly the participants have shown that their explicit needs of school chairs are different to their implicit needs but, with reference to the ergonomic requirements of chairs discussed in Chapter 2, both are very relevant.

Reflections on methodology
The one-to-one nature of the study gave children of different temperaments a chance to have their say and for the study to move at their pace; children had time to add any writing and detail on drawings they wanted to. This was important, given the range of capabilities in a year one class. However, this meant that each book, and consequently each interview, took me some considerable time to complete. In comparison to the teacher-pupil style relationship that I had created in carrying out the pilot study setting this method created a more symbiotic relationship between myself, as the researcher, and the participating pupils.

Carrying out this study in the classroom on one hand had the added advantage of taking place in parallel with other normal school tasks. On the other hand there were frequent and inevitable interruptions from other pupils in the classroom.

Continued…
An occupational therapist had given advice to the class teacher on how children ought to be sitting at the tables when they were writing, based on her professional knowledge and experience. This was for children to sit with their chairs tucked in, to have their feet flat on the floor and to have their backs against the back of the chair. Pupils sitting in this prescribed way would have two advantages for the teacher. Firstly, chairs that were tucked in would also be less inclined to be in the way. Secondly, the children would be sitting properly. The researcher wanted to understand what it felt like to sit in that specific way from a pupil’s perspective.

4.9 Sitting at school part two; seats tucked in

The book making was intended to facilitate a conversation between the participant and me. Unlike other research of this type the content of the drawings produced were not analysed as part of the research. However, Holly’s illustration of herself sitting on a school chair, Figure 4.51, of a happy child blended into the form of a chair, seems to me to captures the spirit of the overall project.
Participants
Ten pupils recruited from a class of twenty-eight to take part in research and design development during the third and final phase of the research during 2014 to 2015.

Procedure
The study took place over several separate days in the pupils’ normal classroom and, whenever possible, when participants were involved in a normal desk-based writing activity. Participants were requested to sit on the chair as the occupational therapist had instructed and whilst they carried out the task, their postures and movements were observed. Notes and still photographs, using an iPhone camera, were taken. Simultaneously, participants’ insights on the way they were sitting were sought by asking them questions directly as they were working. Answers were noted or recorded on an iPhone voice recorder. To minimise disruption to the pupils’ work these sessions, including the questions and answers, were brief. These interventions did not take long and afterwards participants were observed for a short period of time to monitor their postural responses.

The data presented is a collation of five separate data sets that have been assembled from different iterations of the research including:

- Participants’ heights arranged below from smallest to tallest;
- Photographs that represent: a) participants asked to sit as an occupational therapist might request, with their chair tucked in, with their backs against the backrest and feet flat on the floor; and b) where in some instances there are photographs of their responses following the intervention. Red lines on the photographs draw attention to certain points of interest but are not representative of particular anatomical features.

Textual data includes excerpts from:
- Observations noted in the reflective journal;
• Conversations with the participants about their school chairs as detailed above;
• A review of some of these images in consultation with a physiotherapist, Sue.

Findings
Findings are presented, by pupil, and arranged in order of their height starting with the smallest.

Yasmin - height 1078mm

Yasmin was the smallest of the participant group, although it is worth noting that she was not the smallest child in her class. She immediately pointed out that the consequence of sitting with her back against the backrest was that she could not put her feet flat on the floor at the same time, only touch the floor with her toes. Figure 4.52.

She demonstrated that in order to place her feet in full contact with the floor (Figure 4.53) she had to slide her bottom forward, leaving only her upper back supported by the backrest. The red line indicates the approximate angle of her foot, with heel raised (Figure 4.52), and the
approximate angle of her back (Figure 4.53) when her feet were flat on the floor.

When asked what she thought of the chair Yasmin replied: “It's very nice... it's even nicer when I was sitting on the end [front edge] of the chair.” She added that she liked to lean forwards to be close to her work but that she also liked the support of a backrest, it was difficult for her to achieve both simultaneously.

![Figure 4.54](image)

Yasmin perching
Source the author, original in colour

On seeing Yasmin's photographs the physiotherapist's observed that “…this chair is just too tall for her and too long in the leg [seat].”

Yasmin expressed her preference for leaning towards the work on the table but she would also like to use the backrest. However, the combination of the seat height and incline mean that when she uses the backrest she is too far away from her work. Consequently she perched on the front edge of the seat and the chair gets pushed back into the classroom. Figure 4.54.
When Amy was asked to sit in the prescribed way she declared that it was too difficult for her to see her work. The angle of the red lines in Figure 4.55 indicate how only her upper back is supported by the backrest, and that she had to flex her neck to be able to see work on the table.

The physiotherapist commented on seeing Figure 4.55: “...the angle of the neck is such that she’s more likely to be bending down which is more detrimental [to her neck] than being more upright.”

Amy demonstrated the way she preferred to sit in Figure 4.56. The red lines indicate her back looking more upright and natural; she is sitting higher up, and leaning towards her work and her neck is not so flexed, suggesting that she can see better from this position. However, as with Yasmin, the chair is now not tucked into the table.

The two smallest participants of the study both had difficulty in conforming to the occupational therapist’s request, whilst at the same time, being able to see their work. They could also demonstrate that this was remedied by perching on the front of their seat. However, doing so pushed the chairs back into the classroom making them potential hazards.
Although she was the same height as Amy, Molly (Figure 4.57) was able to get her back against the chair and her feet flat on the floor (perhaps her legs are longer), but, in so doing, as the physiotherapist identified, Molly had to crane her neck to see the book on the table in front of her. That her head is not sitting on top of her spine means her neck is supporting most of her head's considerable weight.

In conversation about the school chair Molly said she thought that the chair was comfortable because it was “very soft”. On further questioning it became clear that she was referring to the fine texture of the polypropylene surface. However when asked what would make it more comfortable she replied: “… put some em, pillows… because pillows are… furry.”

What this participant meant by the word “soft” is slightly ambiguous and even her suggestion of adding pillows for extra comfort because they are “furry” is not how we might describe it. However, as tactile experiences “soft” and “furry” are concepts that can be appreciated by all.
Like Amy, this boy, Finn, (Figure 4.58) has his back against the backrest and his feet flat on the floor. However, he is also craning his neck slightly. At the time he said that he was comfortable but within three minutes he had changed his position (Figure 4.59). The seat was no longer tucked in; the angle of his back was more upright and natural. That his feet were tucked back under his seat may be a counterbalancing effect in an effort to keep his body forward.

A short conversation revealed that Finn did not find his chair comfortable and he thought that adding felt to the seat would help. Although Finn’s suggestion of adding felt would not alter the density of a hard plastic seat it might give a more pleasant, tactile feeling and so might make it seem more comfortable.
During a brief conversation Erin commented that she found the chair comfortable. She was clearly able to get her feet on the floor (Figure 4.60) and her lower back against the backrest. However, she is still leaning over from her mid back and her neck is very flexed, and her right shoulder is slightly raised. It appears that the seat could be too low or the table too high, or both.
In reviewing Figure 4.61 the physiotherapist commented that of those that she had seen, Freya appeared to fit the chair best of all. It is tucked in; her back is against the backrest, and her feet flat on the floor. Her neck is not too flexed although her right shoulder appears slightly raised.

However, Freya was not so sure, when asked about using the chair she said: “...its quite comfy but it’s a bit hard and...you have to try and reach to your work.”

Although on a visual assessment the chair appeared to fit this child well this was clearly not Freya’s experience. She had difficulty in seeing her work when using the backrest. As the seat and backrest both incline away from the table it is only to be expected that using the backrest for support would tilt the pupil away from the table and the work. If the tabletop could be tilted towards the child this problem could possibly be rectified. Freya was also was another advocate for a softer seat.
Will - height 1157mm

Figure 4.62                               Figure 4.63
Will
Source: the author, originals in colour

Will was able to sit with his back against the backrest and his feet flat on
the floor (Figure 4.62) but in doing so he appeared to lean over in a
hunched way towards his work. When, in Figure 4.63, he pushed the
chair back a little (by reference to the table leg) his back elongated and his
neck became less flexed.

Will reported that he liked the chair because of the backrest although he
thought that seat felt quite hard to sit on. Like many of the other
participants when asked what could be done to improve the chairs comfort
he replied: “... put a pillow on it.”
George - height 1160mm

George could sit with his lower back against the backrest and his feet flat on the floor indicating the seat height and depth provide a good fit. In Figure 4.64 red lines show how George leant over from his lower back possibly increasing pressure here, although he could have been compensating for that by leaning his arms on the table. The seat may have been too low for his over-all height or the table too high in relation to the seat.

In conversation the physiotherapist, Sue, confirmed that George’s lower back could be “…compromised and flattened… because he’s not using the back of the chair”

Visually the chair appears to provide him with reasonable support and in conversation George gave the backrest a favourable mention.
Daniel - height 1170mm

Figure 4.65
Daniel
Source: the author, original in colour

Daniel was the second tallest participant. Similarly to the previous boy (George above) Daniel could get his feet flat on the floor and his lower back against the backrest (Figure 4.65), implying that the seat height and depth are appropriate for his leg length. However, he is bending forward from his lower back and his elbow is splayed out which could mean that the table is too high and, or the seat too low for his overall height.

Megan - height 1220mm

Figure 4.66
Megan
Source: the author, originals in colour
Megan was the tallest of the participant group, although not quite the tallest child in her class. She was very keen to participate although she was a little self-conscious at times. She placed her feet flat on the floor with ease and had the chair tucked in with her back against the backrest (Figure 4.66). However, rather than sitting up straight, she then leant sideways at an awkward looking angle. Reviewing Figure 4.66 the physiotherapist speculated that Megan’s height might mean that her work was too far away for her to see properly when she was sitting up straight. Tilting to the side could be her way of getting close enough to the work to see what she is doing. Whilst sitting like this briefly is not a problem in itself, holding this posture for any length of time could become uncomfortable.

A short time later the Megan was seen sitting with her body more upright but this time kneeling on the seat (Figure 4.67). It was not uncommon for children to be seen kneeling on this type of chair but previously only smaller pupils had been observed doing this.

Key points
Participants asked to sit in a particular way, as described by an occupational therapist, on an appropriate size British Standard compliant chair had different responses. Smaller children could not put their feet flat on the floor and use the full support of the backrest whereas children with longer legs could manage both. Regardless of how well pupils appeared to fit the chair, when it was tucked in the sitter tended to have to crane their neck in order to see their work on the table. This was rectified, particularly for smaller pupils, when the chair was moved further back from the table and pupils could perch on the front of their seat. Two pupils stated that they preferred to sit that way and others were observed moving into that kind of position of their own accord. The drawback of perching is that there is no support for the back and the chair becomes at least a nuisance by getting in the way or worse, a potential trip hazard.
A visual assessment of the photographic images indicates that perching on the front of the seat places children higher up in relation to the table, and their work, giving them a better viewing point. Although several children said they liked having a backrest to lean on, they also need to lean forward to reach to reach their work, which moves them away from the supporting backrest and suggests that the backrest is in the wrong position.

Furthermore, a number of pupils could achieve some backrest support but, because of its incline and that of the seat, they were again positioned far away from their work. The result was children craning their necks forwards to be able see their books. Some, perhaps those with longer legs, could get their lower back in contact with the backrest but still tended to lean forward from their lumbar region. Neck craning and bending the spine in the lumber region have the potential to cause problems for long-term spinal health. Taller children who could make full use of the backrest devised other means of getting close to their work e.g. tilting sideways. Pupils’ inclination was to get their bodies into the right position regardless of how they were asked to sit. Children like to have the support of a backrest but like the height of the seat it needs to be appropriate for the individual.

The combined seat height and depth was too great for some participants. However, that the seat and backrest are both inclined serves to tip the sitter backwards and away from the work that they need to be able to see. We can conclude then that this type of chair is not designed to support school children carrying out a piece of work at a table; it is not an effective task chair. Children naturally try to counter this design issue by perching on the front of their seats. It would therefore make sense for a chair to be designed that would support them accessing their work in a more natural way.

On the question of comfort, several children described the chairs as hard. Their suggestions to counter this revealed softness to be a quality that
children equate with comfort. Those who made suggestions on improving comfort used the word ‘soft’ to mean either texture (‘furry’, ‘felt’) or density (pillows). In Chapter 2 the perception of comfort was seen to be highly subjective and associated with a sitter’s aesthetic evaluation of a chair. Therefore the tactile finishes of school chairs could affect pupils’ perceived comfort.

Investigating the children’s experience of using the classroom chairs as prescribed has given insight into why they don’t use them as a teacher might expect. The pupils expressed explicit needs; some relating to how they preferred to sit, others about comfort. Children did not talk specifically about postural comfort but about being able to reach and see their work. Their comments on comfort were about tactility rather than posture.

Observing their seated posture and subsequent movements assessed children’s more implicit needs. The chair used in the study was not only a poor fit for most of the participants but it also prevented them from getting close enough to their work. There is a need, therefore, to provide a seat with a backrest that supports children’s natural spinal posture and helps them get closer enough to their work. This needed to be explored in more detail. Surface texture, although important, could be a secondary consideration and is more relevant to pre-production prototype evaluation.

Should teachers need to tell pupils how to sit as well as how to work? The design of the chair in the study certainly meets the most basic need of a school chair, a device to sit on, but falls short of fulfilling a teacher’s and pupils’ actual requirements.
Reflections on the methodology.
Prior to carrying out the study described above, I had undertaken research with children in the same classroom space during three separate academic years. Following the pilot study, which occurred in the first of those academic years, I altered my means of interacting with the children several times in an effort to get a clearer insight into their experiences of using school furniture.

Whilst carrying out the study, 4.9 Sitting at school part two; seats tucked in, I realised that the most effective means of eliciting pupils’ insights was a combination of observation (recorded in photographs) and simultaneous on-the-spot interviews, carried out whilst pupils used the chairs. The advantages with this were: 1) it was a more authentic representation of a school experience because children could carry on with their usual work and; 2) it was time efficient in that the pupils could participate whilst disruption to their school day was minimised. Arriving at this method may not have been possible had I not spent a considerable amount of time in the classroom getting to know, teachers and pupils alike. Without that investment of time in building good rapport, it may have been more difficult for me to judge the best time for this direct interaction to take place.

Additionally, the time that I had spent talking to each class about the research project meant that the children knew what the project was about; pupils who were interested had an opportunity to express their opinions to me whenever they felt inclined.

4.10 Prototype design development
The third research sub-question that had been set for the project was:

“What designable features could be identified and developed to improve ways of supporting these [teachers’ and pupils’] needs?”
The completion of several iterations of research with pupils, and their teacher, had provided valuable insights and identified problems with the currently accepted chair design for primary school pupils. In order to determine better ways of supporting the needs of teachers and pupils, the information gathered from the studies was critically analysed in conjunction with ergonomic information on seated posture from literature reviewed in Chapter 2. A table below (Figure 4.68) categorises the needs of the class teacher and pupils revealed by the research, describing and relating them to designable features of chairs.

<table>
<thead>
<tr>
<th>Need Category</th>
<th>Need Description</th>
<th>Feature requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task appropriate</td>
<td>To support table-based work – <em>doing</em> as opposed to <em>listening</em></td>
<td>Appropriate seat form and height</td>
</tr>
<tr>
<td></td>
<td>To fit different sizes of pupil</td>
<td></td>
</tr>
<tr>
<td>Comfort</td>
<td>Implicit - Able to support dynamic sitting and open angle postures</td>
<td>Higher seat that potentially affords an astride posture</td>
</tr>
<tr>
<td></td>
<td>Explicit - Back rest support</td>
<td>To support natural spinal shape</td>
</tr>
<tr>
<td></td>
<td>Explicit - texture and density (density could affect physical support)</td>
<td>Material finish to feel soft</td>
</tr>
<tr>
<td>Space efficient and safe</td>
<td>Compact</td>
<td>Overall form to be minimal and streamline</td>
</tr>
<tr>
<td></td>
<td>Support modes of working - not to inhibit proximity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Features (e.g. legs) to be streamline</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.68 Summary of teacher and pupils’ needs with chair feature requirements
Briefly, teachers’ and pupils’ needs could be summarised as being fulfilled by chairs that are comfortable to use, task appropriate and space efficient. Based on the results of the research carried out with the class teacher and pupils the answer to the sub-question posed above is that rather than looking at features of chairs as we know them and redesigning or altering them in some way school chairs need to be designed for a different paradigm of sitting from the conventionally accepted, right angle way.

There is a summary of the research leading to the prototype development below. This refers to discussions from previous sections. The relevant section is indicated in brackets.

Summary of research leading to prototype development
The research project has shown that the school’s expectation, based on out-dated social norms (section 2.3) and a particular paradigm of sitting (section 2.1) - that pupils ought to be sitting in a particular way when they are working - is problematic. Pupils were observed to be engaged with their work despite assuming an array of positions including standing, perching, twisting, tipping their chairs and kneeling on the floor (sections 4.4, 4.6 and 4.8).

That pupils should be comfortable over time was a key factor for the teacher (section 4.3). This is a reasonable expectation to have of school chairs, for teachers and pupils alike. However, when pupils made themselves comfortable on the chairs it was seen to cause problems: 1) because the chairs got in the way; 2) pupils were not conforming to school expectations and; 3) another professional had advised that the children should use the chairs in a specific, right angle, way.

Maintaining natural spinal curvature is important to seated comfort, as is some movement (2.1). Design deficiencies of the archetypal classroom chair were identified. The seat height was often too high or too low (section 2.2). The school chair is designed to support a right angle way of sitting employing a backrest to shape the sitter’s lumbar region, despite
each person’s back being a different shape (section 2.1). Research with pupils indicated that provision of a backrest is important and that its shape could be uncomfortable particularly in the lumbar region (sections 4.6). Most importantly the archetypal chair has been found to be deficient in providing task appropriate support (section 4.9). The archetypal chair is predominantly used for doing as opposed to listening but the design is better suited to support the latter.

Moreover, the literature review discussed different ways of supporting seated postures stemming from Eastern cultures (section 2.1) and demonstrated how an open angle posture can support a person’s natural spinal curvature. This is an area open for exploration in designing chairs. Other European countries have adopted some of the principles consistent with open angle sitting. Mandal’s chair designs had higher seats and his research (Mandal, 1984) set out a means of calculating their height in relation to the intended user (section 2.2). German school furniture design research favours movement being incorporated into the school day with dynamic sitting (section 2.2). This prototype development was to combine elements from both, by testing a moving chair concept. The study was to investigate whether pupils of different heights would be able to use the same seat height by sitting in a way that supports an open angle posture thus allowing a natural lumbar curvature, and also encouraging dynamic sitting.

That the perception of comfort is subjective makes this a difficult area to explore and the research has shown that children equate comfort explicitly as a tactile experience of material density and texture (section 4.8). Tactility is a material concern that can be considered later in design development and as part of the manufacturing process. It is more important that the chair’s functional features are determined and refined first.

That a chair should provide suitable support for the task being carried out was another factor identified as one that affects its comfortable use
(section 2.1). Pupils’ implicit expression of comfort can be observed through their postural adaptations when dealing with the one-size-fits-all furniture provision (section 4.9). Despite the design of the chair going against their instinct to move towards their work, and direction from an adult to sit in a particular way, children naturally adapted their position to be able to see and reach their work. This natural inclination was also supported by the prototype to be tested.

Additional background to prototype development
The researcher had previously developed a chair for primary school pupils that children could sit astride and that tilted as they moved towards their work. This was designed to support an open angle style of sitting and to encourage dynamic sitting. The design was registered in 2010 and licenced to a company to manufacture and market for a fixed timeframe; this was still in operation at the time of the research. The project presented an opportunity to test the product’s effectiveness with pupils of different heights in a real school setting. However, after taking legal advice, this was ruled out as it was deemed inadvisable under the terms of the licence.

The original design (Figure 4.69) had been developed in a studio setting using seat height determined by a small group of participants rather than a specific calculation. Consequently, to maintain momentum in the research process, a decision was taken to apply Mandal’s seat height calculation to a tilt-able form that pupils could sit astride and to test this with different heights of participants. Beginning with a re-evaluation of the seat height the intention was to redevelop the original design in the light of research carried out with pupil participants. The study was to investigate whether children, in the same class at school, but of quite different statures could use the same seat height if they were adopting an open angle seated posture. Then, having determined the most effective seat height to develop an appropriate backrest form. This was to require being open to pupils’ comments and acting on observations of the prototype whilst in use, whilst at all times maintaining a flexible approach.
The prototype development study was carried out in the classroom using the combined methods of observation and on-the-spot interviews described in section 4.9 above.

**Participants**

This phase of research took place towards the end of the third year of research in the classroom. The children for this study were selected from the existing participant group according to their height. Altogether five children were recruited for this phase. The tallest, (Megan) and smallest (Yasmin) and a pupil (Charlie) - who was closest in height to the group average - were the main three. The second tallest and second smallest of the participant group were also asked to join the study in case any children were absent on research days. The study had prior ethical approval from the University’s Arts and Humanities College Research Ethics Committee (A&H CREC). Informed parental consent and pupil assent were obtained before the study began. The prototype was only used when the researcher was present and all alterations to its form, as result of testing, were made outside the school premises.
The research took place on a number of different days and because design amendments were made in a workshop remote from the school this phase took place over several weeks. The researcher liaised with the class teacher on the participants’ availability. At each stage the proposed activity was explained and pupils were asked to confirm that they were happy to take part.

Procedure: prototype development
The designer’s preferred method was to develop 3D scale models to establish a construction process before making a full size version. Styrofoam, a strong yet lightweight and easily shaped foam, was used to make a full sized prototype to test in the classroom. This needed to be height adjustable so the piece was made in horizontal sections that could be assembled to three different heights corresponding to one third of the participants’ statures (Mandal, 1984). The overall seat heights, based on the main participants statures, were 410mm, 380mm and 360mm high. A dovetail joint was used to connect the parts and ensure that they would be secure whilst the seat was in use. Other dimensions such as width, depth and the angle of the base to allow forward tipping, were established with reference to the original design. A wedge-shaped piece was attached to the back of the seat to prevent pupils from unwittingly sliding too far back. Later this piece was used to determine the depth of seat that was required so that the seat would tip effectively. A cut-out handle was made in the front of the seat so that children could pull it into position.
Figure 4.70 illustrates the prototype in development. - Top left, is a scale model showing a base, mid section and three interchangeable top sections; centre, is a full size version; right, version 1 is shown in the classroom. Bottom left, version 2 has a narrowed top section; centre, version 3 - with cut out handle; right, version 4, has additional base width for stability, and is pictured beside a table in the classroom.

Procedure: prototype testing and development
The seat was placed beside a table in the classroom for participants to test. The researcher showed the seat to each participant individually and described how it functioned. Iterations of the study were recorded visually in still photographs, using an iPhone 5, or video, using a Sony Handycam. Video footage was later turned into still images for ease of editing to making the participants anonymous. Participant’s comments were
recorded digitally using an iPhone 5 or noted in the journal or the researcher’s notebook. Observations of design amendments that were required were also noted.

In the introductory session the table height was also adjusted, using wooden blocks, to comply with Mandal’s (1984) recommendation that a table should be at least half of the height of the person sitting at it. This required a separate workstation set-up and participants had to move away from their work group or partner making a slightly artificial setting. Because of this, in subsequent iterations, the participants’ usual chair was replaced by the prototype wherever they happened to be sitting in the classroom. Observing participants working alongside their usual group of peers presented a more authentic classroom experience although, the table height could not be adjusted and this would have had an effect on the participant’s posture.

There were four iterations of the study. First: the seat was made to adjust to three sizes, each one measuring a third of a main participants’ stature. To begin with all the participants tested the seat at each different height. After testing, the prototype was adjusted according the participants’ feedback and the designer’s observations; the next version was then re-tested.

Following the initial tests all subsequent studies were conducted with the seat at its highest setting and alterations were made to the prototype width at the top and at the base. In the final iteration the backstop was adjusted to a position where the participants could sit comfortably but in a position where the seat would tip naturally with their movement towards the table.

Findings
Four of the five participants were recorded using the seat during this development phase, the three main participants were Megan, Yasmin, and Charlie and, as the second tallest participant, Daniel stood in for Megan
when she was absent for a number of weeks. The date that each test took place on has been added in brackets.

**Megan**

(10.02.15) Megan was the tallest participant and very keen to be involved but quite shy. At 1220mm tall she was 140mm taller than Yasmin, the smallest participant. To start with Megan appeared not to want to sit astride the seat and used it like a conventional chair quite successfully, considering its narrow width. Figures 4.71 to 4.76 show Megan first on a school chair and then using the prototype from its lowest setting to the highest. In this first session the table height was correspondingly increased with the seat height.

When asked for her opinion, like many children participating in the project, Megan’s first comments were on the texture of the material and she suggested a pillow might make it “a little more comfier”. She liked the middle seat height best (Figure 4.74) but, and more importantly, indicated that the side edges of the top made sitting astride uncomfortable. She seemed reluctant to move much or to try tipping the seat and the physiotherapist commented that it looked like Megan lacked confidence in using the seat (Figures 4.75 and 4.76) because she was trying to sit on it in a conventional way.

Figure 4.74 shows Megan using the seat mid height and with the table at the highest setting. The distance between the seat and table appears to fit her well as her back is quite straight, but her legs appear too long for the seat height. Figure 4.76 shows Megan on the highest seat and table setting and this appears to fit her best although her lower back is more slightly rounded than in figure 4.74, this could be rectified if she sat astride and tipped the seat forwards. That she was reluctant to do this prompted the seat top to be amended by removing the corners.
The next time Megan tested the seat the side edges that she had found uncomfortable had been removed to make sitting astride more comfortable for her. She approved of the alteration and, although she remained keen to take part still appeared a little self-conscious sitting on the prototype.

(23.04.14) Megan had been away from school for a number of weeks. When she tried the seat for the final time it was whilst she was doing her normal school work, at a standard classroom table. By this time the base had been altered to increase the width giving more side-to-side stability.

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78 This event was recorded and reviewed as a short video. There are no accompanying still images presented.
(Figures 4.77). Megan commented on the prototype: “Feels like the normal chairs but a bit comfier,” although she could not pinpoint exactly why she thought this.

![Figure 4.77 Megan 2. Source: the author, originals in colour](image)

(24.04.15) The following day, still happy to take part, initially she seemed self-conscious and remained quite still (Figures 4.78) until the researcher moved away. A compilation of the resulting images appears below (Figure 4.79).

![Figure 4.78 Megan 3. Source: the author originals in colour](image)

Notes from journal 24.04.15:

“… Megan was quite static when I was beside her taking photos. I moved to the other side of the room and watched from a distance… she moved around much more.”
Figure 4.79  Megan 4,  Source: the author, originals in colour
When observed from a distance Megan seemed more relaxed and when she moved, the seat moved with her as she twisted from side-to-side and occasionally tipped it towards her work (Figures 4.79). Megan looked quite at ease but clearly she was still not totally taken with the design because when asked if there was anything that could be done to improve it she replied “It could have things on the side to make it more stable.”

Because of Megan’s height and the relatively low setting of the standard school table it is hard to make an assessment from the images on how successful the seat is in supporting her. In comparing figures 4.71 and 4.76 (above) there is a distinct difference in her posture between using the standard school table and chair and using the prototype and table adjusted to the highest settings. However when Megan was not aware that she was being observed she appeared to be physically more active when using the prototype seat than she was when sitting on a conventional school chair.
(10.02.15) At 1120mm tall Charlie was closest to the average height of the participant group (1131mm). A physically active child (Figures 4.80), and in contrast to Megan, when he sat on the prototype he immediately began to twist and turn and tip the seat. He liked that he could move and twist on it and his only negative observation was on the colour.

In Figure 4.81 the seat is at the lowest height. Although he was active on each of the different seat heights he appeared to be most comfortable on the middle setting (Figure 4.82). The physiotherapist commented on the ease with which Charlie could rotate the seat at this setting.
After testing the highest setting Charlie mentioned that it was a bit hard. Figure 4.83 illustrates that it was more difficult for Charlie to sit astride the seat at the highest setting.
(19.03.15) However, once the seat width had been reduced, Charlie was equally active using it at the highest setting and was also observed tipping the seat from side to side (Figure 4.84). This sometimes looked a little too precarious so the next adjustment that was made to the prototype included an increase the width of the base to provide more stability. Charlie’s comments were slightly inconsistent describing it as “comfy and a bit hard” yet “wobbly and good”.

Figure 4.83 Charlie on the highest seat height
Source: the author, originals in colour

Figure 4.84 Charlie moving on the highest seat height
Source: the author, originals in colour
Figures 4.85 and 4.86 show Charlie sitting on a school chair and the prototype respectively. The prototype seat provides better support for his writing position, as his shoulders are less hunched than on the standard chair. His overall alignment is also improved, as he is not sitting in a twisted manner. However, like Megan, the higher seat and the standard table height combination means that he has to flex his neck to see the work properly.

![Charlie using the school chair and the prototype](image1)

Yasmin

At 1080mm tall Yasmin, the smallest in the group, was often observed sitting on the edge of her classroom chair (Figure 4.87). She thought the prototype felt “funny” to begin with and that sitting astride was sitting on “…a pretend chair” and decided that adopting a more conventional position (Figure 4.88) was more like “a real chair”. An indicator perhaps of how early in life conventions can become acceptable.

Initially Yasmin was unsure about sitting astride the seat and commented that it wasn’t how she was used to sitting (Figure 4.89). Also, that the material was a little bit hard. When asked she said that she preferred using the mid-height setting and thought the tipping function was “fun” (Figure 4.90).
Although Yasmin said the highest seat and table height were “great” it did not look convincing (Figure 4.91). She was the only participant who commented that the chair was missing a backrest.
(17.03.15) On a subsequent session Yasmin used the highest setting, after the width had been modified, saying “Its funny, and its high and it feels very nice”; a non-conclusive comment but she appeared to be comfortable enough for the study to continue with the prototype at the highest setting, which by Mandal’s calculation was the correct height for a child 142mm. taller than her.

(24.03.15) “Well it feels nice today… nicer than I thought [it would]” Yasmin found the seat comfortable to use whilst working at the classroom table. On reviewing the images later (Figure 4.92) it was apparent that she was sitting too far back for the seat to tip towards the table in response the backstop position was altered to find the optimum position.
27.03.15 Yasmin enjoyed demonstrating the prototype whist making a drawing (Figure 4.93).

(24.04.15) Figure 4.94 shows Yasmin moving the seat closer to the table by clasping it with her feet. This illustrates how children can learn to manoeuvre objects unconsciously. On a conventional chair pupils were
sometimes observed curling their feet around the chair legs to pull it closer to the table.

Figure 4.94 Yasmin moves the seat with her feet
Source: the author originals in colour

**Daniel**

(17.03.15) Daniel, 1170mm tall, was the second tallest and used the prototype when Megan was absent for a number of weeks. On first trying it he thought it felt “a bit soft” but that it was comfortable to sit on and he liked that it rotated with him.

(24.03.15) Daniel thought the prototype was comfortable to sit on but could not explain why. In Figure 4.95 Daniel is almost kneeling on the floor when using a school chair. Figure 4.96 shows that he is better supported by the prototype although he is possibly too far back on the seat for it to tilt towards his work. This was taken before the backstop was adjusted.
(27.03.15) The photographs in Figures 4.97 were taken from a number of still images taken during a two-minute sequence of Daniel using the seat. He can be seen to tilt the seat back and forwards whilst concentrating on the drawing that he was working on.

Figures 4.98 and 4.99 demonstrate that because the seat has been designed for sitting astride, when Daniel stands up his legs do not push the seat back into the room as is the case with a conventional seat. This was highlighted as causing problems in section 4.3.
Figure 4.98
Daniel stands up without the seat moving back
Source: the author, originals in colour

Figure 4.99

Key Points
This was a small study with four participants intended to test a prototype’s height and to investigate further design developments through interaction with representatives of the end user group. It took place successfully in a working school capturing the real world experiences of the participating pupils. However, because of the natural setting, the table height remained fixed for most parts of the study and this prevented a full assessment of the participant’s postures. This was particularly the case for Megan, who was the tallest and so had the furthest distance between her eyes and her work. A higher table could have made a difference to this.

The current British Standard (BSI, 2015) uses popliteal height to determine the correct height of a conventional seat. The prototype was testing a different type of seat, and way of sitting, intended to be higher than normal so that the sitter would assume a more natural open angle seated posture. The study was a step towards determining a means of calculating a range of size parameters that could be applied to this type of design. The study has found that Mandal’s theory for open angle sitting, of a seat being one third of a person’s height, is not effective for this type of seat because the smallest participant was quite comfortable on the highest seat that was intended for a pupil 140mm taller than her. However, it indicates that the seat type is suitable for a wide range of
height of pupils in the same classroom. Further research would be required involving a wider range of sizes of participants to arrive at final solutions. It was also found that comfortable use of this type of seat, at the highest setting, was related to the seat width. Narrowing this made the seat more accessible to a wider range of sizes of participants; there is scope for more research here too.

In terms of resolving some of the problems caused by the standard school chair, most significantly in this study it has been confirmed that this type of seat design can support both open angle and dynamic sitting. This is achieved by allowing pupils to tilt the seat so that their natural inclination to move toward their work is supported, as are more natural postures. Participants were able to rotate the seat demonstrating a swivel action without requiring a special mechanism. This type of seat moves but has no moving parts. Furthermore, that pupils sit astride the form has the potential to reduce the incidence of seats being pushed back when children stand to reach something. So long as the overall depth of the product is kept to a minimum this could help with the need for space efficiency.

A number of alterations were made to the prototype in response to participants’ comments and researcher’s observations. The original design had a seat height of 350mm. The final version of prototype had an increased seat height, 60mm more at 410mm. The original seat width was 150mm (with a rounded edge for comfort); the prototype seat width was 95mm with a chamfered edge. The base of the original seat was 150mm; this was increased to 190mm to reduce side-to-side movement. In the final version the seat backstop was positioned 140mm behind the base tipping point. This information forms the basis for design modifications that can be built on with further research and prototype development.

Although the study consisted of several iterations and a number of amendments were made, there are more aspects to be developed to define a fully functional piece. Pupils had indicated in earlier studies that a
backrest is important and so the next step would be to incorporate this feature into the design. This study, along with others in the project that have included pupils as research participants, has shown how valuable their opinions are in helping to understand particular matters that affect children. Further research with pupil participants to develop the prototype could bring to light more new ideas that could be incorporated into this design or that could inspire other solutions.

Reflection on the methodology

Although the results were not totally conclusive because the prototype development requires more work to be done, the methodology was successful in that different heights of the prototype design were tested with pupils in their classroom as part of their school day. The method was time consuming, although this was partly because the school and workshop were located over 50 miles apart. Yet, there was time to listen to and respond to the children’s thoughts and I noticed that even Megan became more relaxed about using the seat with time. There is always likely to be an element of novelty and ideally when the product is more complete a longer-term study would be required to see how well the design works over time when it is just part of the furniture.

In terms of data collection methods at the start a video reorder was used to capture the movement of the children using the prototype but I encountered some problems that caused me to stop.

In each class there were children whose parents had not consented to their participation or who had opted themselves not to join in. It was not possible to confine video footage solely to the participant group because other pupils moved around the classroom often straying into the field of vision. Of course these sections could have been edited
out however, a further problem arose in having to make participants
data anonymous to comply with ethical guidance. I lack the technical
expertise, and equipment, to pixelate video footage and relied on the
lengthy process of extracting still images and editing these instead.
This led to the final difficulty.

The physiotherapist would view the images of pupils when we
discussed their postural behaviours. Because the pupils in the video
footage were not anonymous she could not review it with me and, as a
result our conversations were confined to still images and therefore
mainly to static postures. I had witnessed the pupils in action and had
reviewed the video data so I was familiar with their patterns of
movement, the ways in which they adjusted or positioned themselves
on the seat and the postures that they were moving between.

It would have been helpful to have more feedback on movement from
the physiotherapist. However, our earlier consultations had equipped
me with an insight into her views on seated posture. Furthermore,
through my training and experience of teaching yoga I have learned to
assess peoples’ postures and to develop ways of encouraging my
students to alter their positions to suit particular yoga poses. Usually
this involves either verbal direction or a physical demonstration but also
includes using accessories such as foam blocks for support. Similar
principles are being applied when I work with participants on developing
the design of a chair.

Finally, it was interesting to watch Yasmin grasp the seat with her
ankles and pull it forwards towards the table. This is the sort of
invaluable information that comes from human centred design research.
Chapter 5 Findings: Other influential people

The overall project began as a user-centred enquiry to ascertain the needs that primary school pupils have of their school chairs. During the course of the research the scope widened, taking a human-centred approach to include the views and opinions of other stakeholders associated with school chairs. Pupils are the principal users of school chairs but, early on in the project, the class teacher was identified as a secondary user and so became a participant. Likewise, through iterations of research other professionals were also identified as also having an influence on what is bought, and why and ultimately on how furniture products are used by pupils in the classroom. Therefore, the research scope widened to include other influential people.

Having identified, from the confines of a classroom, the pupils and teachers’ requirements of school chairs this section explores the school chair in its wider social context in response to the final research sub question:

“How are these needs [teachers’ and pupils’] affected by other influential peoples’ perceptions of the furniture, its use and their purchasing criteria?”

The research has established that the requirements teachers’ and pupils’ have of classroom chairs are not being met by the standard provision. It was also observed that the advice of another professional, in this case an occupational therapist, could affect the way that pupils were asked to sit on the chair. It is inevitable that pupils have to use the available school chairs as and when directed by their teacher but like the occupational therapist, other professional people can also influence what type of chair is bought for example and so, in a broader context, how that chair is used.

Other professionals’ influences could come from within the school via its own staff or internal processes, or from beyond those confines; for example, from the class teacher’s professional training or, as was seen, through another related professional’s input.
Findings from interviews with influential people from within the school, the deputy head teacher and procurement team, are reported first, followed by findings from interviews with three external professionals - an occupational therapist and two university lecturers.

Participating adults signed an informed consent form prior to the interviews taking place. Interviews were recorded on an iPhone and were transcribed by the researcher.

5.1 The deputy head teacher
From early on in the research, Mary, the deputy head teacher was the first point of contact at the school and a gatekeeper for access to the pupils. She was the liaison between the researcher and the staff and was kept informed of the different phases of the research as it progressed. As a senior manager in the school with many years of teaching experience she was also a source of information on school processes and pedagogical practices. She took part in a number of informal discussions before these were formalised in an interview that took place in her office.

Mary confirmed that the school’s business manager and premises officer purchase items of furniture, with input from the relevant class teacher. An exact furniture specification might depend on functionality, available space and any specific needs of pupils and teachers. Purchases were made in line with school’s classroom environment policy and she supplied a copy of this document (Figure 5.01).
THE CLASSROOM ENVIRONMENT

will be an inspirational educational environment for children, staff, parents and others; an environment that is all about learning, that children use to learn and are proud of.

By learning environment we mean...

- Classrooms - what should they look like?
- Corridors - what should be on the walls?
- Playgrounds - what are they for?
- Role-play areas - how should they be organised?
- The staff-learning environment — what do staff need?

Key principles

- Classroom displays are a learning resource, and a place for celebration of previous learning
- Corridor displays are a reflection of previous learning
- Some displays are 'permanent' — museum-style, as constant reminders

Core beliefs

- The surroundings in which children learn can greatly influence their academic performance and well-being in school
- The better the school looks, the more it inspires the people inside it
- Pleasing surroundings will definitely lead to better attendance, improved concentration and a healthy dose of motivation and self-esteem
- Staff need to have a good environment which is adaptable to their day-to-day professional needs
- The more attractive, well-lit and colour co-ordinated school classrooms are, the better pupils will feel
- A well cared-for classroom can make pupils feel that what they achieve and how they themselves are perceived is important

Figure 5.01 The school’s classroom environment policy (20.01.15)

The policy outlines the learning environment in very broad terms by incorporating most of the physical spaces that children would use, inside and outside. However, the key principles focus exclusively on displays and generally implies that environmental aesthetics affect well-being, self-esteem, academic performance and motivation, yet at the same time omits the objects that connect pupils and their work to the physical classroom space; school chairs and tables.

In describing the school’s changing attitudes to teachers’ chairs Mary implied there is a degree of flexibility in the application of school policy and that feedback can instigate a change.
Mary. “…it would be again what fits in with the school policy because about year or so ago, we decided to get rid of teachers’ desks and in particular teachers’ chairs because, when you are teaching you should be up and walking about and getting involved. We felt that by having a chair people tended to sit on the chair… But I know a couple of teachers then came back and said standing all day is not conducive to their physical health so then the business manager did a risk assessment and then… he’ll then try and find something that suits their needs.”

Discussion ensued as to how the school sources their educational furniture. The local educational authority allocates an annual budget to the school. Members of the schools management team, the head teacher, deputy head or business manager then established priorities for the school’s expenditure including a provision for upgrading furniture. However here was no specific policy or guidance on where to source furniture.

JL. “... the building manager and premises officer will be the people to talk to about where they would look for inspiration for buying and what would restrict their choice?”

Mary. “ I think inspiration might be a bit optimistic.”

During the meeting Mary offered the following observation:

Mary. “…It’s interesting isn’t it really because you’ve got the contradiction in schools of, or in education, where you’re at the forefront of, you know, ideas… but actually if you think about schools they haven’t really changed since Victorian times in terms of the furniture or the layout or you know in terms of having lots of children in quite a small space and having to do a lot with them… No one’s looked at or changed the furniture in a long time.”

Asked for her thoughts on why little had changed Mary responded:

“… there’s no one really in school who concentrated on that so much so it’s just, it’s not a priority. I would say you are involved in the business of just educating the children you probably don’t think too much about [the furniture] or you probably don’t have time… its then having that strength of character or bravery to just kind of trial it in one class rather than replace everything that you’ve got.

Mary speculated what might cause this situation to change and for different furniture to be considered:

Mary. “ I think the fact that they had trialed it… that the research was based like yours, in a school… and children’s opinions were taken into
consideration… you just really need to be clear on the benefits... and I think if I'm being completely honest I would say the benefits in terms of posture and health are probably secondary to how you can actually use it in the classroom for different subjects.... I'm not saying they should be...”

As a concept of “good sitting” has been observed during the research
Mary was asked if she could explain what it was and what its origins might be.

Mary. “I would say as a teacher you want to see that people are actually looking at either you when you're talking... or looking at who ever else might be talking. And for certain things, for example if they are handwriting… you'd want the posture to be, you want them to be in the chair their back straight and then you know holding their pencil so that, in a way, in a way where they can actually, move their wrist and their hand so that they can do these kind of curves.”

JL. “Is that something that comes through experience? Is that something...that teachers are taught or... something that is handed on through generations of teachers?

Mary. “I think it’s through experience. No, I think it through generations of teachers.”

JL. “... So can I conclude that good sitting or a concept of sitting well in school could be more to do with behaviour than to do with [good] posture?”

Mary. “I would say it’s probably, definitely behaviour for learning rather than posture.”

Summary of key points
Mary summarised the paradox of an education system at the forefront of ideas and yet facing the similar pedagogical and environmental challenges as previous generations. In furniture provision the priority was “behaviour for learning” over good posture and the two do not appear connected79. Educating comes with time pressures. Changing the procurement of furniture would require someone with “strength of character” and the confidence that such a change would ultimately be beneficial for learning.

79 Mary was not asked directly about what school furniture should be offering pupils or teachers when the subject comfort may have been raised.
However, there is flexibility in the system indicated by the scope for change in response to feedback. In addition the school manages its own finances and so would not need to appeal to a higher authority to make furniture procurement changes.

5.2 The procurement team
The business manager (BM) and the premises officer (PO) had bought new tables and chairs for the classroom at the centre of the research a few years earlier. JL was interested to find out about that process from their points of view, including who was involved and what criteria might apply for selecting a particular type of chair. The interview took place in the business manager’s office.

The business manager’s role is in administering the school’s finances whereas the premises officer is responsible for practical resources including repair and maintenance of furniture. In procuring furniture they work as a team each bringing their own expertise. The premises officer had worked in the school for twenty-two years and the business manager for seven. During those seven years the head teacher had changed five times and with each new principal came a new set of priorities.

That pupils were comfortable to work was one of the class teacher’s, explicit needs. However, her ability to deliver comfort was compromised because to a large extent she has no choice in the matter. The furniture was already in the classroom. The business manager confirmed that the school holds its own budget and elaborated a little on how that would be allocated for items like furniture.

BM. “…we make decisions based on well I suppose how much money we’ve got left in the budget for what we can replace within various classes so we’ll try and put a furniture budget aside every year and then on a rolling programme replace things as we go along.

JL. “…is that done in consultation with... the board of governors or with staff?”
BM. “The head teacher, myself and obviously the premises officer, because [the PO] he’s worked in schools for way, way longer than I have so anything furniture wise I always ask his opinion...”

The premises office outlined the procurement process for chairs. A teacher may approach him to replace or repair furniture in their classroom. The furniture was replaced on a like-for-like basis.

PO. “So straight away I’d look for height wise basically... and what age group of children we’ve got in there... I mean basics is like getting a tape measure out and just measuring sort of like the height of the chair... getting a child perhaps, you know to sit on it, but like we know pretty much we’ve got the right height in all the classrooms so like if, for instance we had to get new chairs or tables now... I’d still do a measurement of the height of the chair and the height of the tables...”

JL. “That are in the classrooms now?”

PO. “Yea, just to check sort of like against sort of like if we’re looking in catalogues you know what size we’re going to get.”

Replacement furniture was sourced from educational supply catalogues or the Internet. Prices were compared but were not the only consideration, product suitability, as demonstrated by conforming to the British Standard for example, was seen as important

BM. “… we obviously it would need to be the right product for the children and then we’d look to find that product at the best price... it’s not always the cheapest option we go for because that’s not always the best thing.”

When asked what might provoke a change:

PO. “I think that would be down to the head teacher wouldn’t it? I mean she would say to us ‘I’m not quite happy with... what’s in the classroom, can we look at something?’ And she’d give us an example of what she’d want.”

BM. “Or if they’ve see the benefits of it somewhere else so they may see it at a head’s conference or somewhere they can see how that would benefit learning.”

In an earlier meeting the class teacher had commented that she didn’t like stacks of chairs in the classroom because children play on them. The premises officer confirmed that from his perspective it was important to be
able to stack chairs because he needed to be able to move them en masse when the classroom was cleaned during the summer holidays. On a daily basis cleaners stand the chairs on top of the tables. On occasions, the assembly halls are used for concerts requiring rows of seating for adults. The premises officer has to move lots of chairs around the three-storey building without a lift; quite a feat for one person. However, he also pointed out that he had supplies of folding chairs stored on different floors for this sort of event.

On the whole plastic chairs were seen to be more durable than wooden but the premises officer also pointed out that most products came with a minimum five-year guarantee.

Summary of key points
The scope for change in procurement policy at an individual school level is evident again and particularly if this can be seen to be in the children’s best interests. Currently the assurance that these are being met is in purchasing products that conform to the British Standard. This ensures product safety but there is an anthropometric bias. There is no means of ensuring that products compliant with the standard will be task appropriate. Without a call for change from the school’s head teacher the furniture is likely to continue to be replaced on a like-for-like basis, thus perpetuating what has gone before.

The ability for chairs to stack clearly has benefits for the premises manager but it is not a key requirement from the pupils’ perspective.

5.3 An occupational therapy perspective
Previously, in Chapter 4, attention was given to an occupational therapist’s recommendations on how children ought to sit at tables in the classroom. Having pupils sitting in this particular way had advantages for the teacher. However, it was problematic for many pupils and was not a posture that could be sustained for long on that particular design of chair.
A consultation, by Skype call, was arranged with an occupational therapist with the aim of getting her professional perspective on two matters: 1) What would prompt an occupational therapist’s visit to a school? 2) From an occupational therapist’s point of view what might be considered a good seated posture for children sitting at a table in school and why?

Through this interview it was established that an occupational therapist would be called into school to assess particular pupils if they were considered to be not progressing as well as expected. An assessment would take into account the pupils’ seated posture in relation to their small motor skills, which are needed for tasks like handwriting.

Erin. “...because if you don’t have stability proximally [closer to the centre of the body] you are really going to struggle from a distal [extremities] point of view in respect to using your hands. We get a lot of endurance issues so the child won’t be able to focus for as long because they are working so hard on trying to keep their core or keep their trunk in extension, it’s very, very hard for them to refine their, their movements as such to use their hands efficiently…”

Many developmental factors can affect a child’s seated posture. These are unique to the individual; just as children in one year group will vary in size, they will also be at different stages of sensory development, both of which affect their balance and posture.

On one hand Erin was an advocate of a right angle seated posture:

Erin. “…obviously 90, 90 in respect of your knee… its about giving them a good base support that they are actually able to engage their core…

...ideally get their hips and then their knees in that 90,90 so that they have a nice stable position. So that’s feet firmly on the floor so that they have a nice stable base to then allow for this extension [of the trunk] from the pelvis.”

However, she also highlighted the need for a good stable base and, she had views on other, different, postures that could be beneficial for them to adopt when working in schools from lying prone, on the floor to standing at
easels. In this respect she seemed in favour of children finding a natural, comfortable position to work in.

_Erin._ “...So it’s whatever works for them really. I always think if they are comfortable and they’ve got stability they will engage and that’s what it’s about. It’s engaging children to learn.”

Summary of key points
Schools could seek an occupational therapist’s professional assistance for children with particular needs. Their clinical assessments and recommendations are based on children’s postural behaviours and their development. This information has been seen to have a bearing on how other pupils use chairs.

That an occupational therapist advocates a right angle sitting position with 90 degrees at the knee and hip joints is contentious. Ergonomic literature indicates that this position is biomechanically questionable and that when tasks require upper limb mobility, such as writing, an open angle is preferable. As a way of sitting it has it has historical roots in social behaviour.

There are many different ways that children could be working in school that would benefit their posture and might also help those less well developed to build the necessary coordination for school related tasks. These are factors that could be incorporated into the design of furniture for primary school children. The finding here adds to the argument that primary school furniture should not be simply be a scaled down version of an adult desk and chair but that it should be designed specifically for use in this context.

5.4 Education lecturers’ perspectives
One of the class teacher’s, earliest comments revealed that school furniture, and how it could best be used to support her lessons, was not something that she had considered before.
Tania. “So I think, it made me think… I just came into teaching and obviously this is how I was taught, this is how, so I hadn’t really thought about the furniture. The only thing I thought about this class is that I’d like smaller tables...”

During the second phase of the research Tania had joined the school as a newly qualified teacher. As a recent university graduate, she arrived in the classroom equipped with theoretical and practical skills to use and develop throughout her career. Although it would have been impossible to go back and examine her actual experiences in order to discover what she learned as a trainee teacher it was conceivably possible to get an impression of this in a discussion with lecturers of student teachers. This takes a wider view of the sub-question on how other stakeholders can influence the use, and purchasing criteria, of school furniture. The aim was to establish what student teachers might be taught about using the classroom environment and furniture to support children’s learning.

Interviews took place in the lecturers’ place of work and a sketchbook containing a selection of visual and textual data generated by the project was used in the interview process to help explain the research underpinning the doctorate. Interviews were recorded on an iPhone and transcribed by the researcher.

Lecturer in Educational Studies
Liz was an Educational Studies lecturer in primary education. The main objective of the interview was to discover what and how student teachers learn about using school furniture in order to support pupils’ learning. Questions had arisen during the class-based research as to what, if any modules on teaching theory related to this matter? Or, as the deputy head suggested above, was this a classroom management skill learned through observing others teaching and through a trainee’s personal teaching practice in a classroom?

Liz confirmed that university modules were about learning theory: “…about development of teaching and learning strategies and development of
subject knowledge”. Whereas knowledge about furniture use was something that student teachers would acquire whilst on placement in a school. “... I would say primarily its gained from them being in the classrooms looking at what teachers do, almost certainly.”

This means that this knowledge is likely to be passed on from one generation of teachers to another with potentially little reason to question it.

The discussion also centred on the ways in which children were expected to sit in schools. Two scenarios that had been observed in the classroom were described. Both required pupils to sit in a particular way (cross legged on the carpet and sitting on a chair with feet flat on the floor and chairs tucked in). What were Liz’s views on good sitting?

Liz. “...I think it’s a behaviour management strategy.... it’s a commonly shared understanding of what that [good sitting] looks like which kind of, reinforces it as a behaviour management strategy so across the school every child will know what that means, and it will be a containing, controlling mechanism... So it’s conforming, its conformity to a particular pattern isn’t it? Its uniformity where the individual needs actually become you know, secondary.... and of course a single classroom is just one classroom within so many within that school and there is that expectation of uniformity of approach to behavioural management or whatever it might be across that school community isn't there? ... It’s that sort of school ethos so that when children move from one classroom to another the expectations are similar. That’s shocking. And I’m just thinking too that when you apologise to parents for sitting on small chairs that don’t suit them. Do we apologise to children? They are less important aren’t they?”

This confirms that in relation to sitting on school chairs the expectations for pupils to behave and conform to the school ethos is a behaviour management strategy rather than being concerned with children’s comfort or postural needs. However, she goes on to explain a possible cause:

Liz. “...There's this ever present anxiety about behaviour management certainly kind of colours everything you do in the classroom; that controlling mechanism… which I think is something to, see it as not behavioural management necessarily but controlling and, and, and, what you do about that... you know furniture is one way of controlling children
because you are keeping them pinned down in particular places… which
gives you self-confidence as a practitioner. So there’s a confidence issue
about, and then being free to kind of work in a space where there isn’t
furniture, actually it makes you a much better teacher\(^{80}\).... I talk to students
about this natural tension the whole time in our role, because we need to
conform, or we feel we need to conform, there’s pressure on us to conform
for the particular model and yet we shouldn’t be doing that. We should be
ture to our own philosophy and pedagogical views of how the children in
our care at that moment in time need to learn and what they need to
learn.”

Establishing recognisable behavioural standards is not simply about
making children conform to a school system but is a coping mechanism for
a teacher faced with up to thirty individual pupils and the demands of a
curriculum to teach. This is a knotty issue from a furniture design
perspective. How to design products that will challenge the status quo
without adding to the pressures already felt by those in the teaching
profession?

Lecturer in Primary English

English is a key subject in the National Curriculum for primary schools and
Jan was a lecturer in Primary English to student teachers; what did her
students learn about children’s posture that they could put into use in the
classroom?

Jan. My subject is English so when I’m talking to students about children
sitting at tables I’m talking about their posture for writing and supporting
their writing…”

Jan was knowledgeable on ergonomics and the effects that core stability
and foot positioning could have on hand writing. Later she revealed that
she had learned about these matters from an occupational therapist that
she had worked with whilst practicing as a teacher. Being more specific
about what she would teach, she commented:

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\(^{80}\) Conversely the class teacher tells of having more control when children
are sitting on the carpet, as there are fewer distractions.
Jan. “I’m talking to the students about making sure that… when they [pupils] are writing that they actually are sitting square and sitting straight…”

“…I’d say [to pupils] before you start to write make sure you’ve got your chair tucked in and you’re sitting straight and comfortable and you’ve got your feet flat on the floor…”

This is a reiteration of the occupational therapist’s advice to the class teacher in section 4.3. The difficulties that children faced when trying to comply with these instructions were revealed in section 4.9.

When asked what she thought it would take to alter the status quo in school furniture Jan suggested that it would need to be seen to be enhancing learning in some way although she also acknowledged that:

“…it makes sense doesn’t it if a child is comfortable and able to concentrate and not distracted because they are uncomfortable the they should be able to learn at a, a deeper level or concentrate more than a child who is fidgeting and uncomfortable…”

This view was held in common with the occupational therapist, that comfortable children would be more likely to be able to concentrate and are more likely to be learning.

The discussion covered purchasing classroom furniture and equipment and Jan commented that, in her experience, often people with no experience of using items in a classroom purchased them by consulting a catalogue. She added that she would encourage her students to take a more active role in such matters.

Summary of key points
In a primary school the concept what good sitting is appears to be rooted in a particular pedagogical strategy to clarify behavioural expectations that the school has of its pupils. How children are taught to sit when they are learning to write, for example, is something that student teachers learn from being on placement in schools, either though observing other teachers teaching or by practising in a classroom. Generally, sitting in
school is more about social expectations of uniformity and control to which pupils and their teachers are required to conform. It would take great confidence to try something different. However, Jan draws a connection between pupils’ comfort and their level of engagement, which is an important point for education and for design.

4.3 Implication for the research

That furniture does not appear in the school’s classroom environmental policy is not surprising given that there is little reference to it in government guidance for those constructing or refurbishing schools and in health and safety literature. Its presence in literature is most prominent in ergonomic reports of a lack of physical fit and the consequential back problems for pupils. The Design Council report (Bond et al, 2002) on the procurement of school supplies was critical of the system driven by what was available; this has not yet changed and is unlikely to do so whilst products like chairs continue to be replaced on a like-for-like basis. The issue is compounded by a lack of training for those who buy the chairs as well as the teachers who direct their use. Awareness needs to be raised on the biomechanics of sitting and how this differs from social and cultural associations of seated postures prevalent in the school system. This is not simply a design problem. Social and cultural factors also affect the ways in which school children use the chairs, as much as the design does. This is a multi faceted wicked problem. Innovation in school furniture design is not something that can come about through design practice alone. It needs an approach that is rooted in pedagogical practices, one that incorporates an understanding of end user needs: collaboration between schools and designers, with pupils at the centre. This is as much a question of innovation in education as it is in design.
Chapter 6: Conclusions

The main question underpinning the research was discussed in Chapter 1 and is reiterated here:

“What will a human-centred design approach reveal that can be used to develop designable features for primary school chairs?”

The research undertaken in this doctoral study has shown that the currently accepted design of primary school chairs is not fit for purpose in that it does not adequately support primary school pupils in the tasks that they are undertaking. Their design is more appropriate for supporting listening rather than doing. Therefore, the short answer to the question posed is that, rather than requiring the development of new or additional chair features, primary school chairs should be designed to suit a different way of sitting altogether.

A longer discussion of the overall research question is presented below and related sections from the thesis are noted in brackets.

6.1 Discussion of the research
Although primary school pupils are the chairs’ end users, the literature review illustrates that they are not consulted in the design and development of school furniture. They have no voice. In addition, the design of the archetypal primary school chair is a scaled down version of an adult chair, implying that children have similar requirements of a chair, albeit scaled down in size. Furthermore, there is a lack of specific, ergonomic requirements that could be used for designing meaningful alternatives. In response, the main body of this original research was carried out over three years in a working primary school environment. It is supported by further investigations into factors from the wider educational setting that also have impact.
The overall aim of the research project was to find ways to improve the design of primary school chairs for the benefit of children’s long-term wellbeing. This has been achieved and furthermore, complexities surrounding this issue have been revealed. Findings from field research identified that the primary school chair design, as it stands, assumes that children will adopt a right angle seated posture (4.7). Yet, an ergonomic literature review (2.1) revealed that sitting this way is likely to have a detrimental impact on their lumbar spine and could cause long-term physical problems. Compliance with the British Standard would suggest that school chairs should afford a good fit for most pupils. Nonetheless, field observations revealed that a British Standard compliant design does not provide task-appropriate support for primary school pupils. The angle of the rake of the seat and backrest actively encourage pupils away from their work at the table (4.9). Two different paradigms of sitting, open angle and dynamic sitting, were identified in the contextual and literature review (2.1) as originating in biomechanical knowledge as opposed to being derived from the social and cultural values behind a right angle seated posture (2.3). With few exceptions, other types of educational seating currently on the market are designed around a right angle posture and, of the alternatives only one is available in sizes to suit young primary school children (2.5).

Comfort was identified as a key factor in the success of a chair’s design (2.1). The research managed the complexity of understanding comfort from another person’s perspective by gathering two types of data. Analysis of this brought to light that children’s explicit perception of comfort is based on tactile associations related to material density and surface texture (4.6, 4.8, 4.9). Children’s more implicit experience can be understood by observing their postural adaptations when using a chair and relating this information to ergonomic theories of seated posture (4.3, 4.4, 4.6, 4.9, 4.10).

The importance of incorporating children as participants in design research has been justified. Their contribution has shown that children of
five or six years of age can give voice to experiences that are relevant and are useful contributions to design development. Their familiarity with the chair in school is unique and cannot be imagined by an adult. Pupils articulated where they preferred to sit and why (4.8). They also spoke of the discomfort caused by particular features of their classroom chairs, such as the front edge of the seat or the shape of the backrest (4.6, 4.8). Other strands of the research revealed the wide variety of postures that pupils adopt when they are working in a classroom (4.3, 4.4, 4.6, 4.8) and how they move to compensate for an inadequate chair design (4.9). That children were observed in a range of different positions when they were working in the classroom does not guarantee that they were learning. However, these postures can inform school chair design development to ensure better support for classroom activities.

Simultaneously, by taking a human centred approach the research was able to study factors from the wider primary school setting that also have bearing on the project’s overall aim (Chapter 5). In essence, this revealed that any improvements made to the design of primary school chairs are unlikely to be taken up by the education system, regardless of potential long-term benefits to children. This is, in part, due to a socio-cultural fixation with a design archetype.

Chapter 2 disclosed that during the latter part of the last century the very system created to make good quality, affordable school furniture available to all has resulted in school chairs becoming a commodity (2.4). In addition, the last significant tranche of funding in education, the Building Schools for the Future programme, was set up in such a way that classroom furniture\textsuperscript{81} was often marginalised in favour of architectural showpieces. To make matters worse, the current wave of investment, the Priority School Building Programme does not include finance for furniture such as classroom tables and chairs, meaning that schools are likely to retain old furniture in new or refurbished accommodation (2.4).

\textsuperscript{81} This refers to loose furniture such as tables and chairs, fixed furniture was include in the building costs.
Until the latter part of the last century educational furniture was designed with reference to pedagogical practices and ergonomic research of the day (2.4). Having been seen in 1960s England as an educational tool, school chairs now have no perceived educational value beyond the most basic of providing a place to sit (2.4). Recently, at a national level, school chairs have acquired negative associations by being cited as the cause of low-level disruptive behaviour when children tip or swing on them (2.4). This is supported, in part, by a study reported in this thesis (4.3) but, as the same study also reveals, in reality the matter is far more complicated. The teacher requires classroom chairs to be comfortable to use over a period of time. Ergonomically this equates to affording appropriate physical support to pupils working on specific tasks (2.1). However, because the chair’s design does not provide this, pupils attempt to overcome deficiencies by various means such as, sitting or perching on the front edge of the seat, or by tipping the seat forwards. The field research shows that children who perch are trying to see and reach their work but in doing so, chairs get displaced, becoming obstacles or trip hazards in the classroom (4.9). The design of the chair is a problem for the pupil and also causes problems for the teacher, but in different ways.

For pupils, the act of sitting at school remains influenced by the Victorian era of upright respectability (2.3, 2.4). The research revealed that in primary schools there is a concept of good sitting (4.2). However, it also found that this is not about postures being conducive to wellbeing, or even comfort, but instead about maintaining order (5.4). Classes need to be managed but when it comes to sitting, teachers have insufficient information on the physical consequences of some of their expectations of pupils. The connection between sitting as good or bad behaviour is so powerful that children’s comfort can be overlooked despite being acknowledged as a desirable state. This is exacerbated when teachers follow the advice of occupational therapists, who have sound biomechanical knowledge, but apply it too generally in this instance (4.3, 4.9, 5.3, 5.4). That said, an occupational therapist’s knowledge of the effects that a child’s stage of development can have on his or her natural
posture (5.3) would be of value in the design of seating and of other products that are appropriate for school children.

There is little scope for change in classroom management practices, revealed in Chapter 5, which are passed on through generations of teachers who learn their craft from observing other teachers and through their own practice (5.1, 5.4). The status quo is endorsed by the wider system. Not only is school furniture currently missing from educational policy at a national level, but locally too. This study revealed that school furniture did not feature in the school’s classroom environment policy (5.1). Furthermore, procurement practice is on a like-for-like basis, replicating what has gone before (5.2). A British Standard compliant chair fits the bill. Yet a chair deemed ergonomically appropriate for a school would not meet many of the requirements of an adult office chair (2.4). The school chair is a significant factor in the classroom environment. It connects pupils to the physical environment of educational architecture. In addition, by supporting pupils carrying out schoolwork, the chair supports their efforts to learn and so connects them to the wider educational system.

6.2 Summary of design guidelines arising from field research
The field research found that teachers’ requirements of school chairs are broadly ergonomic: to meet these perceived needs chairs should provide pupils with task appropriate support and they should be comfortable to use over time.

For a chair to be comfortable for children it is important that their implicit need for appropriate postural support as well as their explicit requirement for material softness are taken into consideration. However, each matter may need to be resolved at different stages in a chair’s development. As the chairs are mainly only in use when the children are actively engaged in table-based activities, they should be designed to support this by actively supporting pupils in a position where they can see and reach their work without assuming an unnatural posture.
Children like the support of a backrest but the type of back support that they require is different to that of an adult. They also like to be able to move and stretch their legs.

A primary school chair should be light and safe enough for a child to move on to change posture and should not prevent pupils from getting close to a partner to share equipment and books. It should be safe and easy for young children to move about the classroom.

In addition, from a teacher’s perspective chairs also need to be compact and space efficient.

Primary school furniture could also be designed to support pupils standing, kneeling or even lying on the floor to work, although this may not suit all teaching practices.

6.3 Contribution to knowledge
The original empirical research detailed in this thesis makes seven significant contributions to knowledge on the design of primary school chairs. The research has:

1. Demonstrated deficiencies with the existing primary school chair design in its ability to provide adequate task appropriate support for primary school pupils by studying the postural effects of the chairs in use.
2. Outlined design guidelines for children’s seating requirements that can be used to inform the development of new chair design concepts by researching requirements that teachers and pupils have of primary school chairs.
3. Identified alternative paradigms of sitting that can be used to develop new designs for primary school chairs based on biomechanics and children’s natural postural instincts rather than
4. Advanced the development of a new type of design for primary school chair by developing the form and specific dimensions with participant pupils in a working classroom.

5. Brought to light current factors affecting the design, commercialisation, procurement and use of primary school chairs by framing the research as a *wicked* problem and consulting teachers, pupils and other influential professionals.

6. Demonstrated the value of involving young children as participants in the design of school furniture by showing that pupils of five or six years old have and can express opinions that are relevant and helpful for designing school furniture that they use in school.

7. Advanced design research methodology for developing school chairs by designing refining, and carrying out research in a working school environment.

**6.4 Limitations of the research**

The human centred methodology used in the research has proved to be effective for capturing different perceptions of classroom chairs. By being confined mainly to one classroom, in one school, albeit over three years, the scale of the study provides rich details on everyday matters associated with school chairs. However, it does not necessarily represent the activities, processes and practices of all other primary schools. Nor does it represent the experiences of all pupils in all primary schools. There will be similarities, such as the curriculum, although the associated tasks may differ with another school’s ethos or a different teacher’s pedagogical approach.

School architecture is another variable and other classes may have more or less available space. A national ratio limits class sizes to thirty pupils per teacher. The field research classes had an average of around twenty-eight children so a class with fewer pupils could have more available
space. All of these factors could vary the furniture requirements to a degree and it would be problematic if there was only one conceivable solution to the problem. However, defining and researching the problem as social or wicked has revealed aspects of its multifaceted nature. It is accepted in this thesis that rather than seeking one correct solution, the problem needs to be dealt with in incremental steps, making gradual improvements in different areas. This also paves the way for developing a range of design solutions to compliment different pedagogical approaches.

The ethical process of requesting parental consent and pupils assent also served as the participant selection process. The implication of this was that the group did not always include the tallest or smallest children in each class, although the difference may only have been by a small margin. However, the project maintained an inclusive approach and one pupil with special needs took part.

The human centred methodology investigated the ways in which the chairs were used to be able to understand where design improvements could be made. Although the practices and processes of those responsible for purchasing school furniture were part of this investigation, again, this was confined to one school. Broader market research, to establish what people buy and why (Norman, 2013), would have required a significantly bigger, quantitative, study and statistical analysis. It could be argued that this information alone could have been used to develop a new chair. However, as discussed in the methodology (Chapter 3), consumers are not necessarily innovators. Market research would be useful at a later stage in the design development process for commercial purposes. On that note, the research was concerned with understanding design issues and developing appropriate concepts. It was not concerned with commercial matters leading to pre-production prototype development. This is another aspect for further research at a later stage.
6.5 Further research

What this thesis has presented represents the tip of an iceberg in terms of possible research, and the related product development that could be carried out to improve the design of primary school furniture. However, without a change of mind-set in the wider education system, pupils are not going to see, or feel, the benefits of such.

More importantly, the dissemination of findings is required to stimulate debate amongst those working in, and concerned with, the education system and the related design and manufacturing fields. The way children sit in school being equated to their behaviour rather than their comfort is a major challenge to be overcome. A teacher may have up to thirty individuals in his or her care so it is understandable that there needs to be an element of conformity. A Design Council report (Bond et al, 2002) recommended that teachers should be better informed about educational products during teacher training. The author agrees but goes further by advocating that they should also be better informed about the basic biomechanics of seated postures and need to consider how things could be done differently.

This is an area with opportunities for continued collaborative design-education research. Professionals from both fields need to engage in joint ventures exploring ways of supporting pupils in comfort to suit different pedagogical styles. The cross stimulation of ideas would hold potential benefits to all, and especially the end users. The results of collaborative research would make a difference to educational product design and have positive implications for educational practice. Funding issues aside, perhaps this research could be incorporated into teacher training and on-going professional development. Furthermore, pupil’s participation has been shown to bring valuable insight and so their continued participation in this type of research is justified and necessary.

Although the initial prototype-testing phase included adjusting the height of the table, this also meant that the test was less authentic because it
required the participant to sit at a separate workstation. As a result participants were not able to take part in their normal group or paired activities. This isolation may also have contributed to some being more conscious of being observed. However, the relationship between the chair and table is critical in providing suitable support and should be incorporated into further studies. Simultaneous seat and table development could achieve more effective end results. The prototype that was tested in this research needs more development with children of an appropriate age to resolve the correct position and shape of the backrest. Also a means of calculating suitable seat height parameters for this way of sitting currently remains unresolved. A solution needs to be found in order to make the design scalable to fit more of the intended user population. Last, and by no means least, the concept needs to be refined with further research and development in schools, and with commercial partners. Preproduction prototypes would need to take into account the tactile experiences that pupils find comfortable.

The research focus was on school chairs, although primary school pupils also spend a considerable amount of time sitting collectively on the floor listening and watching (4.2). That furniture is not used for listening activities presented an intriguing scenario for a furniture design research project. Furthermore, the postural implications of children having to sit cross-legged and unsupported on the floor were notable. A study to test a design intervention was proposed and agreed with the deputy head and the class teacher. This would have involved evaluating postural changes and investigating pupil participants’ comfort. Unfortunately, as not all parents and carers had agreed to their child’s participation it was not possible to carry out this phase within ethical guidelines, so it did not proceed. This is an important area with potential implications for pupil’s long-term wellbeing and so deserves to be included in future collaborative research between educators and furniture designers.

Various studies in this research have illustrated the range of different activities in which primary school pupils take part within one single space
and the variety of postures that they adopt whilst working. This would indicate that, in addition to new chair designs, there is room for new ranges of school furniture. Again this type of product development needs to be collaborative in order to have relevance for the end users but this research indicates that products ought to be designed to support pupils sitting, perching, standing, kneeling or even lying on the floor to work. In particular the use of standing workstations for school pupils has been seen to have favourable results for health and education (discussed in the literature and contextual review, 2.4). These factors suggest standing workstations should form part of any future design-education collaborative research. Consultation with an occupational therapist could also maximise the potential for future designs to support children’s natural stages of development. With this in mind there is also potential for complimentary products, designed on this basis, to be incorporated into areas other than classrooms, such as a playground, thus extending the learning environment.

Another possible avenue, as yet unexplored, would be to gain the insight of Ofsted inspectors and to examine whether the behavioural expectations that an inspector of schools may hold would have impact on the pupil-chair-teacher dynamic.

6.6 Conclusion
Through undertaking original research in a working primary school this thesis had demonstrated that educational practices and processes, as well as chair design compromise the healthier and more natural seated postures that children are inclined to adopt when they are engaged in schoolwork. By reframing what might appear to be a design problem as a social issue this participatory research project has revealed the nature of the problem to be beyond the scope of design, commerce or education alone. All those associated with school furniture need to recognise its shortcomings. As a product the chair’s function is to support primary school children in a variety of classroom activities; it is an educational task
chair. This ought to be the first point of consideration by all those involved in its design, manufacture, supply, procurement and use.

Viewed from the outside, the education system functions from the top down; curriculum, finance, and design guidelines are all promulgated by the government of the day. Nonetheless, regardless of the political persuasions of recent governments, a top down approach to stimulating innovation in education is actively encouraging the status quo as far as classroom furniture is concerned. The government and its advisors ought to ensure that schools have the correct information to make the right choices about school furniture.

There is also room for improvement across the board. This research has indicated where change could be instigated at a grass roots level. Schools control their own expenditure (5.1, 5.2) and can change their own policies in response to new requirements. A school’s senior management team, led by the head teacher, is best placed to instigate policy changes at this level\(^\text{82}\) (5.1). For example, the school at the centre of the study operates a rolling furniture replacement programme. Rather than waiting for change to occur with the next significant tranche of funding, new types of furniture should be added class by class. The post WW2 era saw educational changes in policy, practice and design. Perhaps these similarly austere times could invoke a similar collaborative and creative spirit? This type of change does not need a fabulous and expensive piece of architecture because appropriately designed furniture could be used in today’s educational spaces. Fundamental design issues could also be tackled by a change in pedagogical practices. A moving school ethos might negate the need for a chair that fits 100% of the user population because pupils would be able to choose to work where they are most comfortable.

\(^{82}\) In some schools the board of governors may also be involved in these decisions.
In the field research children were observed engaged in schoolwork whilst assuming a range of different postures. Whether they were actively learning during this time would require different and much longer-term research but it raises a number of questions. What should the value of a good school chair be if not its cost? Should a good school chair be related to pupil attainment and if so how can this be measured? Enhancing pupils’ comfort at school through well-designed furniture could be seen as an aspirational end in itself.

Finally, if pupils are causing problems by swinging on their school chairs, instead of prohibiting this behaviour why not try to understand the reason behind it?

Like a quiet child in the classroom the primary school chair gets away with doing the minimum required, underperforming and not reaching full potential. Its school report should read, “Could try harder”. Those responsible for allowing this underperformance need to look again, from a different perspective, to consider what hidden talents are waiting to be discovered. There is potential for a greater contribution yet and meanwhile children will continue to sit on the edge of their seats.
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Appendices

Appendix 01: Sample Interview Transcription

Teacher Interview 17.07.16 (40.01)

Teacher interview following her participation in a photography project to illustrate where the furniture was working well in her opinion and the times it was nor. We met in the classroom at the end of a school day near the end of the summer term.

00.00

JL “...as I said earlier, I was talking about what needs teachers, I’m interested in looking at the needs teachers have. So I’ve looked from the children’s perspective, had a chat with them and I’m really keen to hear what teachers think”

T “So I think, it made me think about, cos I just came into teaching and obviously this is how I was taught, this is how, so I hadn’t really thought about the fact the furniture. The only thing I thought about this class is that I’d like smaller tables because it takes up so much space and it’s a huge classroom but it would be nice to have a bit more space [yes] and free play areas and that kind of thing [yes] and hidey holes [hidey holes, yea] but I’m not sure about that.” 01.16

The teacher was briefed that a key question in the research is on the needs teachers have of school furniture during the photography project.

T “What I really need from the furniture is a space where children will sit, they will do their work and they’ll be able to access their work. They’ll be able to talk with their partner when its appropriate and, em, well they’ll be comfortable enough to sit there for, I would say I’d be happy with them sitting down for twenty minutes in year one. [yes] Twenty minutes bordering on half an hour, an hour...” 1.47

JL “yes, to be able to sit at one particular place"
“Yea, and they need to be able to write [yes] and writing is really important. [yes] Doing their maths is mostly, not all the time, but mostly its done at tables [yes] which means that they need to write, open a book you need something to rest your book on.” 2.26

Image 01 - Morning Table Layout. The teacher sets this up before the children arrive. There is a book for each child at a place “groups in twos”. The books for the next (maths) lesson are in the middle of the table. The group is arranged around three sides of the table so that all the children can see the teacher at the front of the class.

T  “No one on this one side because they need to be able to face me at the front”

JL “So that very important that kind of layout?”

T “Yea, they need to work in partners, and they need to be able to see me.” 3.13

On Image 02
T “…they were working doing what I had expected them to do here, and I would say it was successful in terms of my outcomes. I wanted them to do the writing, they all had space to use an A3 piece of paper and do writing on it and they were all very calm and they weren’t, they didn’t distract each other they weren’t on top of each other.” 3.24

JL “Is A3 a sort of standard size?”

T “...if you open a book, it is A3...” 03.49

On Image 03
T “Then, this is other pictures of them writing or doing something at a table and its where they’re probably not sitting as expected.” 04.53
This annoys me, the fact that the chair’s not tucked into the table because, it’s a safety hazard for the other children and he’s likely to fall off his chair which actually they do quite a lot.” 4.52

Image 4

“...therefore that chair becomes like a safety hazard because he’s not sitting on it, he’s sitting on it comfortably. This boy, Boy X, is also in another picture. He’s actually in quite a few...I saw him (Boy X) writing quite comfortable on the floor for quite a while.” 6.03  Image 4 (Morning session same day as Image 01)  Boy X not in my group as his parent had not returned the ethics forms

Confirming that Image 01 and 04 are on the same morning sessions

“Boy Y often likes sitting, not sitting down...and he struggles to sit on the carpet as well...so maybe he’d prefer not the furniture that we’ve got.”

6.27

(Boy Y standing leaning on the table.) Boy Y not part of the group - he said he didn’t want to take part although he changes his mind from time to time.
Appendix 02: Adult Participant Information and Consent Form

A Human-Centred Approach to Primary School Furniture Design

Consent Form

Dear

I am a furniture designer and a PhD student at the University of Brighton and would like to invite you to participate in my research project. Attached is an information sheet outlining what I would like to do, the project’s background, aims, aspects of data protection and contact details for the University and myself.

If you would like to participate I will explain what is involved and answer any questions you may have. This should take around 20 minutes. If, after consideration, you agree to participate I will ask you to sign the consent form below.

Please note if you subsequently change your mind you can withdraw from the study at any time without giving a reason and, if you choose, the information you have contributed can be removed from the study.

Yours sincerely,

Jackie Lightfoot

A Human-Centred Approach to Primary School Furniture Design

I have read the project information sheet. Yes

No

I have had an opportunity to ask questions. Yes

No

I agree to participate in the study as outlined in 02 Study Details overleaf. Yes

No

I agree to our interviews being recorded as detailed in 02 Study Details overleaf. Yes

No

I am satisfied that I have been given sufficient information about this PhD project. Yes

No

Signed (participant) ……………………………….. Date…………………..

Print name………………………………………………..

Signed (researcher) ……………………………….. Date…………………..

Jackie Lightfoot
University of Brighton
January 2015

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A Human-Centred Approach to Primary School Furniture Design

Participant Information Sheet

01 Project Background and Aims
The project is a PhD research project and is funded by the Arts and Humanities Research Council. Its long-term aim is to find ways of improving the design of classroom furniture by using a participatory design approach.

In order to understand different aspects of primary school furniture use I would like to incorporate the views of a variety of stakeholders including; the pupils of a year one class, their class teacher and others involved in using and procuring furniture for the school.

The final results of the overall project will be published in a thesis in 2015. In future and in line with the overall project aims, some of the information and images generated through the research may be exhibited, published and shared with other organisations in design and furniture industries. However, individuals associated with the research will remain anonymous, unless they request otherwise.

The information and consent form has been written in accordance with the University of Brighton’s Faculty of Arts’ Ethical Research Guidelines for Staff and Students.

02 Study Details
Participation is entirely voluntary and if you change your mind about you can opt out at any time without giving an explanation.

The session will consist of an approximately one hour-long informal interview. The discussion will mainly focus on the following from your professional perspective:

Pros and cons of the existing classroom furniture provision;
If appropriate, aspects of buying new furniture.

Sessions will be by prior arrangement and at your convenience and with your permission our discussions will be recorded digitally and transcribed by me before being deleted. If you chose to opt out of the study information you have contributed can be removed.

03 Data Protection
Personal information will be kept on the school premises in the classroom. When the study is completed it will be given to the deputy head teacher for safekeeping and will be shredded following publication of the thesis in 2015.

If you have any questions please contact me, or my supervisor, by email, using the addresses below.

Researcher: Jackie Lightfoot
j.lightfoot@brighton.ac.uk

Supervisor: Professor Jonathan Woodham
J.M.Woodham@brighton.ac.uk

Jackie Lightfoot
University of Brighton
January 2015
Appendix 03: Parental Information and Consent Form

School Seating Design Research Project

Date

Dear Parents and Carers,

You gave permission recently for your child to participate in my school furniture design research project. I would like to add another activity to the research. It is described in detail overleaf and I am seeking permission for your child to take part in this. If, after reading it, you are happy for him or her to take part please complete the consent form below and return it to me at the school via his/her book bag. Participation is entirely voluntary and your child will not be asked to participate without your consent. The University of Brighton’s College of Arts and Humanities Research Ethics and Governance Committee have approved the study. The school’s Deputy Headteacher is kept fully informed of proposed activities related to my project, as is the class teacher.

If you have any questions about the project I will be available to answer them in the playground after school on (Date tbc.) Alternatively, you can email me, or my supervisor using the addresses below.

I would be very grateful if you could complete the form on the next page and return it to the school as soon as possible, indicating whether or not you consent to your child taking part.

Thank you very much for your help.

Yours faithfully,

Jackie Lightfoot

Researcher: Jackie Lightfoot
j.lightfoot@brighton.ac.uk

Supervisor: Professor Jonathan Woodham
J.M.Woodham@brighton.ac.uk

Jackie Lightfoot
University of Brighton
December 2014
Prototype Testing Consent Form

Please circle your responses

I have read the project information sheet. Yes
   No

I have had an opportunity to ask questions. Yes
   No

I consent to my child’s participation in the activity described overleaf. Yes
   No

I am satisfied that I have been given sufficient information regarding this PhD project and hereby make a decision in the best interest of

(Please fill in your child's name).................................................................

Signed (nominated person).................................................................

Print
name.................................................................Date.........................

……

Jackie Lightfoot
University of Brighton
December 2014
Project Information Sheet

1. What would I like to do?
I am designing a new type of seat for primary school and I would like to test it whilst it is in development in the classroom with a small number of specific children. I would like to record its use and stages of development in still and video footage whilst it is being used. During the activity I would be discussing the seat and how comfortable it is, or is not, with the child using it and I would like to record this conversation. Each session would last approximately 20 minutes maximum. The seat would then be altered in stages according to the feedback received from the participating children and it will be re-tested at another time. I expect that this process may be spread over two to three weeks in total and that each child may be asked to take part around three or four times.

During the activity the child will be working on a normal school type activity such as drawing or writing. The table may be slightly different from the usual classroom so that it is comfortable to sit and work at.

Prototypes will only be used under my supervision and they will not be left unattended in the classroom.

2. How will the children be invited to participate?
The activity would be explained to the children and they would be given an opportunity each time to choose to participate or not. However, children without his/her parent or carer’s consent will not be invited to take part in the study.

Participation is entirely voluntary and if a child changes his/her mind, or if his/her parent or carer chooses to withdraw them, they can opt out at any time without giving an explanation.

3. Where and when will the activities take place?
All activities would take place during the current academic year in the school. The time and place will be agreed with the class teacher to ensure that lessons are not interrupted.

4. How will the collected information be used?
The information is to be used in my project to design and develop new prototype furniture for primary schools. The final results of the project will be published in a thesis, and in line with the project’s overall aims, may be exhibited, shared and published with other organisations in the design and furniture industries to develop new types of school furniture. The thesis, or extracts from it may appear online.

However, images of children would be made anonymous by cropping or pixelating faces or other identifying features before being published or shown to third parties.
5. How will personal data be protected?

Personal data, including images, will be kept and used in accordance with the 1998 Data Protection Act.

Paperwork containing personal data, such as consent forms, will be kept in the school by the deputy head teacher and will be shredded after three years. Personal information for cross-referencing, e.g. names and measurement information, will be coded in order to make it anonymous.

Digital photographs and video will be downloaded and kept in a password-protected laptop and password protected external hard drive. These images will be made anonymous (as detailed in 4. above) before they are shared with any others in the future. As with personal data, any digital images deemed to be of no further use would be deleted within three years.

Digital sound files would be stored on a password protected laptop and external hard drive and deleted after being transcribed by me. Children’s identities would not be revealed in the transcription.

If a child choses to stop participating or if his/her parent or carer wishes to withdraw them then any material relating to them will be removed from the study.

6. Who to contact with any questions:

If you have any questions please contact me, or my supervisor, by email using the addresses below.

Researcher: Jackie Lightfoot
Woodham
j.lightfoot@brighton.ac.uk

Supervisor: Professor Jonathan
Woodham
J.M.Woodham@brighton.ac.uk

Jackie Lightfoot
University of Brighton
December 2014
Appendix 04: Child Information and Assent Form

School seating design: a user-centred approach
Participant Information Sheet

My name is Jackie

I would like you to try my new school chair design and tell me what you think of it

I would like to take photographs of you and video you working in your classroom when you are sitting on this new seat.

I would like you to tell me what you think of the chair design when you are using it.

Some of the information will be put into a book called a thesis and may be shown in an exhibition and shared in other ways to help make school furniture better.

Jackie Lightfoot
University of Brighton
December 2014
My name is

Date

The project has been explained to me and I understand it.

I have asked questions that I wanted to and I know that I can change my mind about taking part at any time if I want to.

Yes, I would like to take part

Or

No, I do not want to take part

Jackie Lightfoot
University of Brighton
December 2014
Appendix 05: Tipping Chairs
Appendix 06: Raw Anthropometric Data Including 25mm Shoe Allowance

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<th>Participant number</th>
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<th>Class 2</th>
<th>Class 3</th>
<th>Participant number</th>
<th>Class 4</th>
<th>Class 5</th>
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Appendix 07: Examples of Participant’s Books
### Appendix 08: Example of a Participant's Data Sheet

<table>
<thead>
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<th>P20 (B) Harry</th>
<th>07.07.14</th>
<th>H-1140, PH-295</th>
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<tr>
<td><strong>Prefers to sit</strong></td>
<td>On a chair</td>
<td>Because he can put his feet on the floor and move his legs. Blue chair comfy.</td>
</tr>
<tr>
<td><strong>Doesn’t like</strong></td>
<td>The carpet</td>
<td>He gets told off if he moves his legs about</td>
</tr>
<tr>
<td><strong>Seated Activity</strong></td>
<td>“Listening and concentrating”</td>
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<td><strong>Suggested improvements</strong></td>
<td>Soft cushions on the chairs</td>
<td></td>
</tr>
<tr>
<td><strong>Other info</strong></td>
<td>Likes the orange chair</td>
<td>Because its “very comfy and its bigger” Not allowed but uses it when T not looking</td>
</tr>
</tbody>
</table>