Institute of Education, University of London  
Degree of Doctor in Education (EdD)  
**Institution-Focused Study: Submission form**

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A Study of Children’s Views of Mathematical Manipulatives in the Transition from Primary to Secondary

Key words: children’s views, mathematical manipulatives, transition, primary to secondary mathematics;

DOCTOR IN EDUCATION (EdD)

Institution- Focused Study
Abstract

‘Mathematical manipulative’ is a term widely accepted to describe entertaining tactile objects that support symbolic representation of abstract concepts, providing a conceptual framework for social collaboration and discussion. Yet evidence exists within the literature and practice that manipulatives are not being used as effectively or as widely as they could be. An Ofsted (2012) publication “Made to Measure” found, not only is there a skewing of resources with greater use of concrete representations in primary, and virtual representations in secondary, but concrete manipulatives are often reserved for use as a teaching intervention to support the lowest performing pupils. This, therefore, downgrades the value attached to concrete manipulatives. The purpose of this study was to record and report children’s views on the use of a range of mathematical manipulatives prior to, and following, the transition from primary to secondary school. The usual customs surrounding deployment and use of manipulatives within the primary classroom were also of interest.

This study, framed as an inductive exploratory study design, involved a mixed methodological approach to triangulate the research subject (Creswell, 2011). The aim was to derive a range of data sources to construct a detailed picture of the children’s views. The researcher gained employment within the school for just over a year. Data collection involved two research sites. The overall survey sample consisted of 95 students.

The findings reveal while year six children enjoy making use of all manipulatives, they associated the use of concrete manipulatives with younger children or to support children classified as lower attaining. There exists a veiled socialised stigma attached to concrete manipulatives due to how they are deployed. Although it is a small sample study, mathematics educators should be able to relate some of the findings to their own experiences and settings.
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Chapter 1: Introduction

1.0 Rationale

Manipulatives are widely accepted as entertaining tactile objects that support symbolic representation of abstract concepts, providing a conceptual framework for collaboration and discussion. Yet, the term ‘mathematical manipulative’ remains largely unfamiliar in UK classrooms, despite a popular discourse in places such as America and Australia.

Numerous international studies have been conducted in the field of mathematical manipulatives, supported by an abundance of recommendations on how they should be used to engage children in the classroom (Moyer et al., 2015, Parham, 1989, Raphael and Wahlstrom, 1989). Scholars have drawn upon a range of studies into cognitive development, to influence and validate the use of these resources (Bruner, 1960, Montessori, 1989, Skemp, 1987, Vygotsky et al., 1978). Despite this, evidence exists within literature and practice that manipulatives are not used as effectively or as extensively as they could be. An Ofsted (2012) publication “Made to Measure”, found not only is there a skewing of resources with greater use of concrete in primary and virtual secondary, but that concrete manipulatives are often reserved for use as a teaching intervention to support the lowest performing pupils. This can downgrade the intrinsic value attached to concrete manipulatives.

Nevertheless, it could be reasoned that the skewing of resources is justified. As children progress through school they become less reliant upon tactile methods of representation (McNeil and Jarvin, 2007). Still, concrete manipulatives are an additional resource, suitable for all learners to develop their understanding of abstract concepts.
1.1 Personal significance

My interest in this study began as an exercise to find solutions to a professional issue and it has evolved into a theoretical nuisance. The professional problem arose as a teacher, attempting to engage more able year 6 pupils within their mathematics lessons. In my quest to find a workable solution, I participated in a research project involving the use of a range of manipulatives to solve problems. Nurturing Mathematical Promise (2008) focused on empowering teachers with a range of effective strategies that focused upon endorsing imaginative, enjoyable and creative activities through a range of resources. It was fascinating to watch the children using equipment such as Lego and Dienes blocks to solve problems involving symbolic algebraic equations. What struck me, was how much the children enjoyed their lessons when provided with access to a wide range of materials and given the autonomy of choice. Sternberg & Grigorenko (2004) argue further for cognitive effects: “When students are provided with multiple resources, they are more likely to perform at optimal levels” (as cited in McNeil and Jarvin, 2007).

Over the last sixty years, a substantial rise has taken place in the range of manipulatives available in schools which makes their selection more complex (Moyer et al., 2015). Schools are bombarded with a wealth of resources and are often pressured to adopt the latest concepts through the process of endorsement via the newest media campaign (McFarlane, 2014). Furthermore, the head of the department usually manages the selection process with little or no consultation with pupils. I write here from the perspective of one who has held this role for many years. In this role, I was responsible for the management and implementation of mathematical resources. Against my better judgment, I often felt hard-pressed to adopt the latest mass-produced initiative endorsed by the local education authority depending on the agenda and budget available at the time.

In my experience, concrete mathematical manipulatives have an efficacious history of use, providing the perfect platform to communicate abstract ideas to
others. Despite this, studies indicate there has been a gradual decline in the use of concrete resources within secondary education (Burghes et al., 2012). Some authors suggest reasons for this decline. Modern technology has dramatically altered the communication channels causing a ‘cultural shift,’ whereby traditional methods of pedagogy and learning are rejected in favour of the new. Yet, it has been asserted that mathematics should be viewed as a narrative of how old but vulnerable truths are joined by newer ponderables, accreting gradually to the body of mathematics (Jackson, 2012a). Although virtual manipulatives allow opportunities for more intricacy, this can cause complications, especially within the time constraints of a lesson. Furthermore, interactions with virtual manipulatives can have a negative impact on social interactions (McFarlane, 2014).

Due to the change in culture, where virtual methods have grown in prominence, a gap exists in the theory between educators’ efforts and children's responses to initiatives designed to improve participations and perceptions (Skemp and Rowland, 1989, Wolfram, 2014). Student attitudes towards a subject matter can be an important indicator of expected performance/attainment and achievement. The question remains how best to meet the needs of students and present mathematics in such a way as to encourage wider student participation, yet promote the relevance and usefulness of the full range of mathematical resources for meeting the needs of future generations.

Few studies have been conducted into the ‘interchange’ between secondary and primary school children’s views and the use of mathematical manipulatives. There is considerable scope to investigate and better understand children’s views, particularly as mathematics is an important subject that has an impact on career pathways.

Understanding pupils' views could help educators craft more effective and tailored mathematics curricula and teacher training programmes. Addressing these questions may lead us to better understand the needs of students, rather than maintaining a more instrumental approach.
1.2 Aims and objectives of this study

This Institution Focused Study (IFS) aims to examine school children’s views on the use of a range of commonly used mathematical manipulatives in primary schools.

Specifically, it aims to:

(1) record and report children’s views of mathematical manipulatives prior to, and following, the transition from primary to secondary;
(2) describe the usual ways in which manipulatives are deployed within the primary classroom.

This study is framed as an inductive study design involving an exploratory research approach (Corbin and Strauss, 2008). The purpose of this approach is to develop knowledge from empirical observations and interactions providing the foundation for future studies. In this instance, the approach is to record and report views surrounding the use of mathematical manipulatives within two year 6 classrooms prior to, and following, the transition from primary to secondary. This design follows a phenomenological tradition in which participants’ views are deemed subjective, yet valid, forms of social phenomena that require appropriate methodological tools. The methods employed to collect data involved a mixed method approach using a range of qualitative and quantitative methods to triangulate the research topic (Creswell, 2011). This strategy increases the validity of the research providing a detailed picture of the phenomena studied.

The subsequent chapter defines manipulatives and epitomises the historical, and contemporary context surrounding manipulative use.
2.0 Defining manipulatives

Mathematical manipulatives are commonplace in classrooms across the UK, yet they are rarely addressed by such nomenclature. Current terms such as resources, artefacts, tools or instruments of learning are more frequent. However, ‘tool’ is often referred to as an appliance that aids or accelerates work. Using this lexicon dispels any notion of interaction, engagement and enjoyment. In contrast, an instrument can be thought of as contrivance of musical capabilities, endorsing nothing but rendezvous and amusement. This insight fortifies the belief of ‘fun’ at the expense of mathematical conceptualisation (Bouck and Flanagan, 2010).

Furthermore, whilst the expression ‘artefact’ embraces the longevity of manipulative and the significance of sociocultural and historical representation, this terminology is limited in the sense that it fails to acknowledge the embodiment of manoeuvrability.

The above examples illustrate the ambiguity surrounding demarcations within this area. Whilst this discussion highlights the impossibility of an agreed term of representation for mathematical manipulatives, for the purpose of this study they will be defined as objects that can enrich instruction, enabling children to use their hands and learn mathematical concepts more deeply.

2.1 Historical context of manipulatives

Together with the development of language, mathematics has shaped human civilization, providing the mental and physical means to expand knowledge in other areas. Since the beginning of time, many ancient civilisations have drawn upon the use of tangible entities to solve mathematical problems. It is widely accepted that our fingers were the earliest form of manipulative
dependent on the field of mathematics observed (Struik, 1987, Jackson, 2012b, Sousa, 2015).

Central Africa is home to the world's earliest known manipulative used for counting and calculation. The Ishango bone, carved from the fibula of a baboon 20,000 years ago, is believed to be the oldest attestation of manipulative recorded (Jackson, 2012b). Centuries later, archives indicate the Romans and Chinese civilisations introducing resources such as the Abacus as a modified counting tool.

The idea that all learners deserve an equal opportunity regardless of perceived difference. Whilst there are a number of talented individuals who fought to make this possible Pestalozzi referred to the as the father of modern day education.

Early 1800’s philosophers such as Rousseau (1762) propositioned the importance of young children learning through their senses, and he very much approved of the kinaesthetic aspect of education. His voice was one of the earliest and most prominent during the period of the Romanticism, a crusade within Europe that is symbolised by its emphasis on the emotions and aesthetic experiences (Bloom, 1991).

Following this period, studies cite Pestalozzi (1782), a Swiss educational reformer, as being influential in the endorsement of empirical sensory learning with entities. His methodology is believed to have been strongly influenced by Rousseau (1972) theories. Pestalozzi (1782) coin phrases such as “Learning by Head, Heart and Hand” that intrinsically endorse the importance of children’s learning through the sense of touch and drawing on concrete experiences prior to developing abstract concepts (Silber, 1965). Much of the research documents how during this period, the manipulative shifted from dispensers of knowledge, to more of a facilitative role in learning. Educators such as Fröbel (1837) and Montessori (1964) followed, developing educational play materials to support children’s learning. Nonetheless, whilst Montessori educational philosophy claims to involve a child-centred approach
which encompasses child initiated activities, these actions are often designed to take place in a specified location, with precise training. Children are invited to interact with work stations using preselected resources in a prescribed manner, guided by trained teachers (Montessori, 1989). Although these classrooms adopt an individualistic approach to teaching and learning, it can be argued that this method offers a restricted lens of the concrete manipulative by treating it as a play based tool.

Loris Malaguzzi (1971) founder of the Reggio Emilia’s educational philosophy endorses the notion that children are born with a ‘special type of knowledge’ akin to imagination (Cagliari et al., 2016). His approach supported a more lateral, as opposed to hierarchal, relationship between teacher and learner, endorsing learning through the senses (Wharton and Kinney, 2015). He advocates topics that should be explored ought to be dependent upon the child’s interest. Children are invited to explore learning through freedom of choice, endorsing heuristic play, maximising interest and imagination (Cagliari et al., 2016).

Theories relating to this sensory, yet historical, period implicitly touch upon the notion of some of the pedagogic practice surrounding kinaesthetic learning acknowledged today in classrooms. The ability to touch, can be asserted as the most significant sense of all, as it is the first sense acquired and shapes our experiences, particularly when learning (Linden, 2016). Furthermore, the sensation of touch is an instinctive means of non-verbal communication that enables people to build an understanding of abstract concepts based upon interactions with physical representations. Chillot (2013) is quoted in Psychology Today suggesting “The physical sensations we experience early in life become a kind of mental scaffold that supports more metaphorical thinking as we grow older.” The Pacinian Touch Sensors within the finger tips sparks an emotional response, creating memorable experiences (Linden, 2016).

Early years educators also embrace, endorse and value heuristic (practical and discovery approaches) methods of learning. Whilst tactile techniques
can be fun and enjoyable, they also form the initial building blocks to what is known as “associative memory.” Sousa (2015) describes the associative memory as a process where the brain operates by making connections. The long-term memories are stored and are awakened and refined by new thoughts. Sousa is cited, emphasising “The limbic regions in the brain then sprinkle your memories with emotion” (p. 39). Nonetheless, since our responses to tactile sensations are such an individual and unique experience, interpretations of each experience will vary considerably.

Much of the literature relating to the use of mathematical manipulatives has taken place within the last 50 years. The work of Piaget (1952) is repeated as the driving force behind many of the studies, where he suggests children aged between seven and ten years work primarily in the concrete and can only acquire abstract notions of mathematics through practical resources. Skemp and Rowland (1989) research also indicates that a student’s early experiences and interactions with physical objects form the basis for later learning at an abstract level. According to these theories children are not born with the capability for abstract thought.

A number of resources followed, such as Zoltan Dienes (1969) ‘blocks,’ and Gattegno and Cuisenaire (1954) ‘rods’ which were designed to build upon Piaget (1952) theories of learning. Researchers such as Moyer and Jones (1998) also made significant contributions to this field, especially during the 1980’s, where these resources were related to constructivist theories (construction of knowledge through experiences). Manipulatives are used to ‘construct’ new knowledge and constructivists’ pedagogic approaches are by nature more sensory.

Vickers (2001) asserts that much of today’s primary mathematics teaching retains elements of what can be considered “outdated practice,” retaining an undesired empathise on rote and memorisation. In contrast, it can be considered that some traditions are an important aspect of learning. Traditions can reinforce values and provide the shared context for learning, particularly when making use of manipulatives. If creativity is viewed as the
reproduction or retracing of past stimulation and experiences, combined with imagination, then without traditions no context would exist at all (Sharpe, 2004).

2.2 Contemporary context of manipulatives

In recent years, virtual mathematical manipulatives have grown in prominence in the classroom. They are considered digitalised resources that mimic the physical kind. Nowadays, teachers are increasingly expected to integrate technology into the delivery of mathematics lessons. Yet little research exists into the scope, or indeed the limitations of using virtual manipulatives (Moyer et al., 2002, McNeil and Jarvin, 2007).

Furthermore, a singular category of ‘virtual manipulatives’ is inadequate, in the sense that it offers little of the full contrivance of the various representations of this type of resource. Also, the precise role of technology in schools remains unclear, with schools achieving outstanding results irrespective of the technological heart of its curriculum (McFarlane, 2014). McFarlane (2014) claims “After billions of pounds of investment, endless evaluations and reams of policy documents it seems that the precise of technology is unclear. What is clear is that there remains a substantial gap between what effect technology-supported learning and pedagogy could be and what happens in majority of schools”.

Moreover, there appears to be a growing chasm between the types of resources used for teaching and learning mathematics, and policy expectations of how learning is assessed nationally. Standardised Attainment Test (SATS) examinations still make use of traditional tools to assess learning. Computer based standardised assessment have yet to be implemented by the government.

The current standard of mathematics has become a frequent topic of debate where results have been commended and criticised for decades (Cockcroft, 1982). However despite the importance of mathematics as a prerequisite for
further career development, studies indicate the subject remains unpopular at the secondary level with students, and is often viewed as difficult (Askew, 2011).

The utilitarian aim depicts the General Certificate in Secondary Education (GCSE) mathematics secondary as a subject that is often desired by many Universities as an entry requirement. It can be considered as a pivotal subject, underpinning entry to professions such as Engineering, Science, Business and Finance. Yet in the UK, mathematical achievement and participation at secondary school level lags behind other developed nations. A report published by the Programme for International Student Assessment (PISA, 2014) suggests UK pupils are failing to be equipped with the necessary mathematical skills and are unable to compete internationally. This further adds weight to the argument that content, and or delivery, needs to be relevant to pupils’ needs today. Whilst it is reasonable for students to question the relevance of traditional methods of mathematics within the context of the more quantitative digitalised world they are increasingly emerging into, traditional procedures are still necessary today.

At present the government intention for secondary schools in England, is to ensure that pupils understand that:

*Mathematics is an interconnected subject in which pupils need to be able to move fluently between representations of mathematical ideas. The programmes of study are, by necessity, organised into apparently distinct domains, but pupils should make rich connections across mathematical ideas to develop fluency, mathematical reasoning and competence in solving increasingly sophisticated problems.*

*The programme of study for key stage 3 is organised into apparently distinct domains, but pupils should build on key stage 2 and connections across mathematical ideas to develop fluency, mathematical reasoning and competence*
in solving increasingly sophisticated problems. They should also apply their mathematical knowledge in science, geography, computing and other subject (Department for Education, 2013).

If teachers are to successfully implement the above aims, it could be reasoned that a more integrated concrete approach is required in order to improve attitudes towards mathematics, fully utilising the full range of equipment available. Students should also be offered opportunities to appreciate the interconnected nature of mathematics through the full range of manipulatives.

A recent survey by The Teacher Development Trust (2014), found just over half of schools are now struggling to provide adequate resources and professional development opportunities due to funding pressures. This can result in professional development opportunities relating to the use of these of materials reserved solely for ‘experts’ or teaching professionals who struggle with the delivery of mathematics. Furthermore, concrete manipulatives are often discarded when practitioners are unfamiliar with how best to make use of them and are fearful of losing the skill to control and assess knowledge when in use (Moyer and Jones, 1998). It can be extremely difficult to train teachers in the use of manipulatives specifically, as not only are there a multitude of manipulatives available, there are also many ways these resources can be used effectively.

Moyer and Jones (2004b) refer to ‘controlling choice’ as using instructional practices that exhibit control over the manipulatives during the instruction of the lesson. They discuss how teachers exert different control orientations during lessons, conveyed through a range of instructional behaviours (Moyer and Jones, 1998). Controlling choice can remove the element of fun and engagement from learning. Deci and Ryan (1987) research reported that a student’s controlled choice can have an impact on students’ intrinsic motivations and concluded that motivation increased in lessons where children were provided with high autonomy orientations.
At present, there exists a shifting in terms of national expectations within primary mathematics endorsing the use of manipulatives. The National Curriculum (DfE, 2013) for primary schools in England now has three core aims: to be fluent in the fundamentals of mathematics; to reason mathematically; and to solve problems by application. It is anticipated that through these aims, many pupils will achieve 'mastery' of the subject (DfE, 2013).

At the moment it is assumed ‘mastery’ involves the ability to explore mathematical concepts and skills using a variety of representations and problem solving contexts Drury (2014). During this exploration, pupils are also expected to simultaneously acquire mathematical language associated with this mathematical concept or skill to communicate related ideas independently (Drury, 2014). Children are encouraged to physically represent mathematical concepts using objects or depictions, to demonstrate and visualise abstract ideas, alongside numbers and symbols, offering what is understood as a richer and deeper learning experience (Drury, 2014).

This archetypal mode of learning mathematics was inspired by Bruner’s (1966) three modes of cognitive representation (figure 1).

*Enactive stage 1 - involves representing events through motor responses (physical motions and gestures);*

*Iconic stage 2 - involves the storage of information as images or diagrams;*

*Symbolic stage 3 – where information is stored through written symbols codes or language permitting mental manipulation. (Bruner and Haste, 2010)*
Bruner and Haste (2010)’s modes of representation are integrated and are loosely sequential, unlike the age-related stages of Piaget’s theories. Bruner strongly opposed Piaget’s notions of school readiness. Yet mastery schemes of work, implemented within primary schools, are synonymous with age related goals. Furthermore, Bruner (1960) exemplified discovery learning through a spiral curriculum model where concepts were visited simply at first, then revisited at more complex levels later on using a constructivist model.

Bruner and Haste (2010) endorses the importance of learners capitalising on children’s inherent instinct to touch, explore and discover. Bruner’s theories discuss the possibility of learners enjoying their experiences, and progressing beyond these stages towards the capabilities of producing fruitful predictions.

Whilst the notion of mastery learning is principled, the reality of implementation within large classrooms can be complex. Fundamental flaws can occur when replicating the mastery mode of delivery. The manner of implementation within schools can have an impact upon the productivity. Furthermore, the strategies used to implement mastery overlook some of the fundamentals of Bruner’s work. It can prove problematic for teachers to adopt new pedagogic practices within the same policy structures. Although creative, it can be difficult for teachers to organise and assess learning. Children make progress at different rates which can result in some children who are ready to advance, becoming held back from making progress. This can have a detrimental impact on motivation (Horton, 1981).
Moreover, Bruner and Haste (2010) theories acknowledges the importance of the child’s learning environment, in particular the social learning environment. His view was, that the purpose of education was not simply to impart knowledge, but the teachers role was to ‘scaffold’ learning within a facilitative role whereby lessons were designed to permit children to discover the relationship between what is known and what is intended to be discovered (Bruner, 1960).

Similarly, Skemp (1977) discusses the notion of the construction of schemata when assimilating new information. Schemas are used to connect what is already known to new learning. Whilst schemas can be useful as they permit shortcuts to be made in the interpretation process of information, previous stages need to be revisited. He expands on this theory that mathematics is taught and learnt instrumentally and relationally. He defined instrumental learning simply as the traditional pedagogic practice of rote learning where the learner follows set procedures modelled by the teacher (Skemp, 1977). In contrast, relational teaching and learning is defined as a more meaningful process where children are able to establish links between mathematics structures, due to understanding not simply how, but why procedures are followed (Skemp, 1977). Whilst both theories raise distinctive issues, what is clear is the teacher is central to the teaching and learning of mathematics, particularly when using manipulatives.

These theories also raise questions surrounding the point where instruction ends and exploration begins, particularly when using manipulatives. McNeil and Jarvin (2007) research questions if manipulatives adequately build conceptual understanding or if manipulatives serve as a distraction from the formation of symbolic notation of mathematics. Skemp (1987) also discusses the stages of symbolisation and conceptual hierarchy. He examines the process of abstraction and considers if symbolisation only occurs once knowledge established through constant exposure, or if knowledge is an ever evolving process revised continually (Skemp, 1987).

Moreover, valid questions can be raised as to what mastery entails and whether it is indeed achievable, given that knowledge can be viewed as an
accumulative process. Horton (1981) contends that “mastery is an optimistic model for learning which requires wide scale agreement upon the specific goals for attainment.” How the teacher delivers mathematics can have an impact on children’s views of learning (Dweck, 1999).

2.3 Importance of beliefs

Much of the research examining pupils’ views and epistemological beliefs in general has been dedicated to the primary phase. The rationale behind this could be as a consequence of the recognition of the importance of early intervention and the need to support a child-centred approach which currently takes centre stage within UK educational policy (Munro, 2011). This supports the implementation of The Children and Families Act (2014) and the United Nations Convention on the Rights of the Child (1989) which advocate that investing in children is considered investing in the future. This theory is based on the hope of fulfilling individual and social potential in order to accomplish productive functioning adults in society (Ball, 2008, Montgomery, 2013).

A wealth of research is pertinent to teachers’ ‘views’ or ‘perceptions’ in relation to the use of manipulatives in the primary phase (Askew, 2011, Barber and Houssart, 2011, Brothwick, 2011, Furinghetti and Pehkonen, 2002). One can argue that this is because research in this area currently has the greatest impact, as it can address, and put into practice, what needs to be done to assist pedagogy and pupil progress in the future. However, despite this focus on engagement at the primary level of education, secondary pupil participation remains problematic.

Despite the focus on addressing this problem, no studies have focused exclusively on addressing the student view. In addition, there is a scant research base exploring how pupils perceive the relevance of mathematics to their future, or lives in general. This opens the way for more targeted research in this field, including the study proposed here.
There is a wide breadth of research dedicated to understanding and defining the concepts of 'beliefs,' ‘perceptions' and ‘views'. Green (1971), cited in Richardson (1996) refers to the term ‘beliefs' as a judgement that is accepted as true by the individual holding the belief. Green (1971) delves further, describing ‘beliefs' as a psychological concept that is different from knowledge, which implies epistemic warrant. ‘Views' can be thought of as an outlook, a consideration or a personal opinion, whereas "beliefs" can be thought as holding a far deeper reaching impact. Real conviction, trust and confidence can all be placed within beliefs. In contrast, differing research conducted within this field proposes the disparities between ‘beliefs' and ‘knowledge'. Kitcher (1984), cited in Lester and Garofalo (1987) describes the distinction between ‘beliefs’ and ‘knowledge’ as:

"An individual's beliefs may or may not be logically true or may be externally justifiable, whereas knowledge must have both characteristics in addition to being believed by the individual".

This is a justifiable view, as one can hold a very strong conviction that may not have any basis in fact at all. Nespor (1987) and Abelson (1979) refer to ‘beliefs' as a weaker condition than knowing. One could question if any of the research pertaining to beliefs is indeed valid if this is the case, as there is no way of researchers 'knowing' whether the beliefs they think are possessed are held at all.

Many studies have been conducted into what is meant by 'beliefs,' a term which is hard to define and even more difficult to research, due to how ‘beliefs’ are interchangeable and difficult to prove. Social psychologists, anthropologists and philosophers have contributed towards understanding what beliefs entail and the effect on actions. Parjares (1992) refers to ‘beliefs' as a messy construct that can travel under many aliases such as attitudes, values, judgments, theories and understanding. Whether the term 'beliefs' or the alias of ‘views' is used, one is trying to establish a representation of existing thought processes that can affect their actions. Goodenough (1963) is cited in Richardson (1996) suggesting "Beliefs are accepted as guides for
assessing the future, are cited in support of decisions, or are referred to in passing judgment on the behaviour of others.”

2.4 Research Questions

1. How do children describe their use of mathematical manipulatives in the transition from primary to secondary?
2. What is the culture in primary schools surrounding the use of manipulatives?

2.5 Transition – positioning the reader

Transition is the terminology used to describe the transfer of pupils from primary school to secondary school. Typically, within the public education system in England, many transitions take place at aged 11 whereby children may move from the familiar setting of primary school to the unfamiliar setting of secondary school. Within this unfamiliar setting, children are expected to encounter a change in environmental, cultural and social structures within the school (McCormack et al., 2014). Students shift from remaining in one class with one teacher for most of the day to changing classrooms multiple times during the course of the school day, interacting with a variety of teachers and peers.

An Ofsted (2012) publication, “Made to Measure,” exposed a skewing of manipulatives (greater use of concrete in primary and virtual secondary) inspiring my focal point of the transition period. Furthermore, research conducted by the National Research Council (2004) reported a decline in pupil engagement and motivation following the transition into secondary school. Focusing on the transition period provided the participants with the
opportunity to reflect upon views shared retrospectively.
Chapter 3: Methodology

3.0 Introduction

Methodology is broadly defined as the philosophical underpinning used to justify the use of the research methods. It informs the reader of specific strategies utilised to understand the research. The following chapter provides a detailed overview of the methodological framework adopted. A clear rationale is provided for the methods used as data collection instruments.

3.1 Paradigm and study design

Willis (2007) acknowledges a paradigm as a viewpoint of how research should be conducted and interpreted and proposes that paradigms are incommensurable. The pragmatic view is adopted here, where there is no single reality and knowledge is constructed based on individual responses to the world (Robson, 2011). An interpretivist paradigm is also embraced, as societies’ understanding of reality is grounded upon experiences constructed intersubjective. Taber (2009) defines an interpretivist paradigm as ‘Research that is based on a view that all knowledge is based on interpretation’. The interpretivist researcher plays a key role as the ‘social actor’ in drawing out shared meaning through social constructions (Bryman, 2007). This type of research necessitates the subjective recording of human attitudes, views, and understanding. The aim here is not to root out the cause, but to act as clarification of the phenomena, providing a rich description of the experience (Creswell, 2011).

Children’s views were recorded from multiple lenses. Greig et al. (2012) argues: “Research that involves children and young people and the social worlds in which they live needs to be seen from as many angles as possible” (p.62). It was anticipated that this strategy could overcome the biases associated with using a single method and enhance the reliability and credibility of the study’s findings. This strategy also provided powerful authentic examples of typical actions and behaviours in real-time.
The term ‘sociocultural perspective’ is a process used to try to understand why groups behave the way they do. The sociocultural perspective seeks to understand these behaviours by examining the unwritten guidelines that guide or direct actions. Bryman (2012) describes the term sociocultural perspective as repositories of widely shared values and customs where people can socialise, within set rules and practices. In contrast Liddicoat and Scarino (2009) understands the term from an epistemological point of view and expresses sociocultural perspective as a tangible body of knowledge that people may have, or hold, in relation to a particular association.

Yet, there exists a range of complexities when attempting to capture the sociocultural perspective of a classroom. Whilst there are a range of existing practices and norms that routinely make up a typical learning environment within primary schools (such as all children seated on chairs at desks and observing an interactive whiteboard with at least one teacher at the front of the classroom), these customs are not routinely found in every classroom. Furthermore, variances will take place within these standard observable features, such as the dimensions and the look of the classroom, the brand and size of the interactive board, and the size and layout of the chairs and tables used.

In order to acknowledge what can be outlined as the sociocultural perspective of the classroom, research within this field necessitates the observer’s ontological positioning will largely depict their ability to acknowledge redeemable values and traits.

For the purpose of this study, a phenomenological stance was adopted, which acknowledges how my own preconceived values and notions can impact on the lenses that I view the classroom and the interactions between participants. Through the process of reflexivity, I was able to locate myself in the picture of teacher professionalism and critically examine my own limitations, whilst simultaneously appreciate how my teaching and behaviours influences organisational practice and children’s experiences (Fook, 2002). Since
engaging in this process it has compelled me to acknowledge the assumptions I have brought to this research.

To construct a conclusive paradigm of children’s views of mathematical manipulatives, I initially reflected upon my childhood experiences beyond the constraints of my current perspective. I appraised the concept of the teaching professional and mathematical manipulatives through multiple lenses, drawing upon personal and professional critical incidents. I also evaluated my own ideological assumptions. This practice of introspection led me to the conclusion that my views are somewhat shaped by my holistic experiences. As a child, I was denied the opportunity to make use of mathematical manipulatives at school. This has shaped my experiences and views.

Furthermore, this study concedes to the ontological tensions whereby my presence and emergence within the classroom can alter the climate and the culture of the classroom. Nonetheless, phenomenological research determines that the researcher must block out what is already known to capture the reality of the experience first-hand with a fresh view, whilst simultaneously acknowledging their privileged position of intuition (Heron, 1992, Wolff, 1984). For this reason culture will be defined not simply as a body of knowledge related to a particular association, but also a framework which the children live, interact and communicate. (Liddicoat and Scarino, 2009).

**Methods**
Student’s views were recorded using an online attitudes survey (see appendix 1) and semi-structured focus groups (appendix 2). Interpretative approaches rely heavily on naturalistic methods (Creswell, 2011). These methods ensure an adequate dialogue takes place between the researcher and participants, building a more meaningful picture of the reality.

The survey included a five point Likert scale, with a few questions requiring the respondent to produce a more reflective response. The questionnaires
also included a range of demographic questions where participants were asked to indicate gender, ethnicity and age.

Following the survey, a small sample of students took part in four semi-structured focus groups, recorded in groups of 3 using a table top Dictaphone in conjunction with scribed notes.

Focus groups data provide the opportunity to uncover information which may not be present within the survey data. The data generated presented the opportunity to confirm or challenge the findings from the survey. Focus group data also provided an opportunity to reveal expansive emotional responses and offered an opportunity to disclose possible causes of behaviours, or views, that are held (Merton et al., 1990) and furthermore proposition an explanation between stimulus and effect (Vaughn et al., 1996). The participants were provided with the opportunity to reflect on their responses to the survey. This strategy created a context for the participants to reflect upon their experiences introspectively, and describe them in more detail (Bryman, 2012).

Focus group data is best utilised within exploratory research, as this flexible design provides opportunities for spontaneity and direct contact with research participants. Furthermore, focus groups support the phenomenological nature of reality whereby multiple views of the same phenomena can be explored and discussed at the same time.

Interviews were conducted with a random selection of willing participants. The purposive sample of year 6 children were nominated to participate within the focus group discussions and were selected based upon empirical observations. All participants provided consent (see appendix 4).

Naturalistic classroom observations were conducted over 20 weeks, recording the spontaneous behaviour of the participants and any relevant discussions within the children’s natural classroom environment. Photographs of the
manipulatives used were taken for the duration of the study to cross reference with the observational notes and survey results.

**The sample**

The study focused on year 6 pupils from a local school. I was employed within the school setting for over 8 months. In order to gain a detailed understanding from empirical observations and interactions. The survey was completed by students from all four year 6 classes (n=95 response rate).

**3.2 Data analysis**

To address students’ views, a sequential mixed method design was adopted which involved collecting and analysing both qualitative and quantitative types of data to triangulate the research subject (Creswell, 2011). Whilst qualitative and quantitative research are separate paradigms, mixed methods encourages the use of multiple views. This approach was taken because neither qualitative or quantitative methods were deemed sufficient to capture the breadth of experiences surrounding the use of manipulatives (Creswell, 2011). The quantitative data provided a general picture of students’ experiences, whereas the qualitative provided a compelling description of these results by exploring the views held in some depth. Mixed methods enhance explanations and provide cross-validation (Creswell, 2011). It was anticipated the iterative approach (within method) would improve confidence in the findings, providing more than one way of appraising the concept (Bryman, 2012). The aim was to derive a range of data sources to construct a detailed picture. It was anticipated that this strategy helped provide a more complete picture of the research problem increasing the validity of the research. Significant insights of children’s views surrounding the use of manipulatives in the classroom could also be drawn.

Data was analysed using thematic review in order that themes, correlations and inter correlations could be identified (Yin, 2013). This data was categorised and conceptualised (Corbin and Strauss, 2008).
This empirical project also made use of qualitative and quantitative methods to contextualise and honour the voice of the participants and provide a complete narrative in the form of two context rich vignettes. This multi strategy approach provides a detailed picture of the phenomena being studied, spanning viewpoints and provided the opportunity to compare the types of data, albeit from different perspectives.

3.3 Ethical issues and risk to participants

The current rhetoric of including the voice of the child, has grown in prominence and has become almost commonplace within the field of research and education (Allison, 2007). Article 13 (UNICEF, 2013) endorses the right for all children to share their views relating to matters that affect them, yet a debate exists whether the researcher can truly represent that voice. The researcher’s role was not simply to just let children speak and present the findings. It was to explore the unique contribution of children’s experiences, in order that decisions can be made with their best interests at heart. This supports the aims of Article 3 (UNICEF, 2013).

A second related theme surrounds the debate of the ontological position of childhood and what it is to be a child and whether children’s views are valid forms of epistemology. I adopt the position here that, although children may be classified as biologically immature in comparison to adults, they are nonetheless competent and articulate commentators who can actively contribute to and shape the world in which they exist (Greig et al., 2012).

The UCL Institute of Education necessitates that all students gain ethical approval prior to conducting research. An application was submitted to the supervisor and advisory committee for review, prior to the initiation of the study.

The Children Act 1989 (HM Government 1989) positions children as vulnerable, placing forward various procedures in order to protect children when conducting research. The Children Act (2012) enforces that children should be consulted about matters that affect them. As this study was carried
out with minors, informed consent from all participants was sought (Opie and with Pat, 2004). All children who participated within the study were provided with access to an information sheet detailing the study. Participants who gave informed consent were given with the right to withdraw at any time. A letter and information sheet was also issued to the school gatekeeper for distribution to the parents/carers of the children involved (appendix 4). This letter included a brief introduction detailing the study and how the results will be disseminated.

The United Conventions of the Rights of the Child (UNCRC) also recognises the tension between children’s rights to protection and the right to participation. Article 12 of the UNCRC requires that all children who are capable of forming their own views should be granted the right to express their views freely in all matters affecting them, commensurate with their age and maturity (Graham et al., 2006). This study permitted children to take advantage of this right with the support of their class teacher and parents/carers.

It was not expected that this research would raise sensitive material; however as a precaution the information sheet stated that the researcher might not be able to guarantee complete anonymity should children disclose a safeguarding issue that impacts on the safety and wellbeing of the participants.

Children were accompanied by a member of Senior Leadership during the focus group interviews. All participants were afforded the right to refrain from responding to any questions without penalisation should they feel the questions posed were of a sensitive nature (e.g. attainment set, ethnicity). I complied with safeguarding procedures in line with current best practice. The identity of participants was not disclosed and all issues related to confidentiality were in line with the British Education Research Association (BERA) guidance and Data Protection Act (1998).
In accordance with the rules of consequentialism, I formed a partnership with the gatekeepers of the schools, whilst remaining mindful of the ethical commitments (O’Reilly et al., 2013). An up to date Disclosure and Barring Service (DBS) certificate was held. It was anticipated the partnership formed would help eliminate administrative issues such as access to the research participants and the potential impact the research could have had on allocated study time. The survey and interviews were conducted at a time that was suitable for the children. I worked closely with the gatekeepers to discuss the requirements in relation to the information sheet (e.g. access restricted to the class teacher to read out, or for distribution to each child) and the procedures for consent in line with the school’s policy. The gatekeepers and class teachers involved were provided with access to the survey prior to administration.

**Data storage and security**

The British Education Research Association (BERA) written guidelines were adhered to when storing data. The online survey results are cloud encrypted to private access. All data from the survey and interviews were anonymised with the allocation of codes and password encrypted.

All participants and parents/carers were debriefed following the collection of the data to ensure that the participants had not been adversely affected. Participants had the opportunity to reflect upon their contributions, ask questions and to be thanked for their contribution (Morrow and Martin, 1996).

**3.4 Limitations of methodology**

**Insider research**

‘Social situatedness’ can be viewed as a concept relating to the idea that the development of individual intelligence requires a social and cultural influence (Vygotsky et al., 1978). It also denotes that multiple perspectives are required in order develop a thorough understanding of a given context (Tedlock, 2000).
and ‘situatedness’ arises from the interplay between the researcher, the situation and position held by the researcher and the context of the classroom (Lave and Wenger, 1991). Therefore, the organisation of the classroom can have an impact on the validity of the research. However, by using the ‘insider’ approach, the children were more comfortable, established trust and were able to retain their normal social interactions providing a wealth of knowledge an outsider would not be privy to (Tedlock, 2000). I could talk more freely and openly with the participants.

I am mindful that it could be inferred the small sample could affect applicability, nonetheless the insightful generalisations discovered can help reform pedagogic practice surrounding the use of manipulatives.
Chapter 4: Research Findings and Discussion

4.0 Introduction

The following chapter reports the findings in respect to the two dimensions examined within the study. The first dimension of the study describes the findings of children's views of the use of manipulatives prior to the transition in the form of the results of a survey and focus group interviews.

The survey made use of a five-point psychometric Likert scale to measure views. The results of the online survey were collated into a matrix sheet in Excel. Pre-coded ‘ordinal data’ was then aggregated into pivot tables and charts allowing significant insights to be drawn. A distribution of responses from the survey can be found at appendix 7.

Interviews were transcribed and the retrieval process began with the researcher reading through the text and divided the interview transcripts into nodes, making note of any major thematic codes identified. These nodes were then reorganised into coding frames (cases) where the following major themes were identified: Opinions relating to attainment grouping and manipulative use; memorable resource; Controlled choice; Expectations of Secondary school.

A combination of data sets was used to increase the reliability of the data providing a deeper insight into the views held from multiple perspectives and to overcome biases associated with methods. It also enabled the researcher to discover the relationship between the children’s views and possible actions that could impinge on the views held.

The second dimension of the study describes the culture surrounding the deployment of the use of manipulatives utilising two context-rich vignettes.
4.1 Survey

Although I was interested in the context surrounding the deployment of manipulatives, the primary lens of observation was to capture children’s views surrounding the use of manipulatives. The survey collated opinions or preferences across a range of questions regarding the use of manipulatives in the classroom.

Opinions relating to attainment grouping and manipulative use

The term “attainment grouping’ is used here to describe a system of allocation whereby pupils are allocated to groups according to the attainment results of national tests or perceived ability in mathematics (Ireson et al., 1999).

Appendix 7 reports the results of the online survey (n=95). As expected, the demographic data indicated a fair distribution between genders. Surprisingly, just 3% of the students surveyed identified themselves as belonging to the lower attainment set. Most of the students surveyed (48) identified themselves as top set. This result was not anticipated. Further analysis of the transcripts found the result could be attributed to social desirability.

Unexpectedly, only 67% of the students surveyed identified a preference for online mathematics in comparison with 71% of the survey indicating practical mathematics activities were more interesting and exciting (table 1 below). This result contrasts with current research of the CITEd's Research Center (2015) within the literature review. Whilst the literature indicates a significant rise in the use of virtual manipulatives, the results of the survey indicated that children still prefer to use concrete methods. However, although most of the students surveyed indicated a preference for practical resources, 48% of students were undecided if mathematics equipment were outdated. This finding supports the initial research detailing a ‘cultural shift,’ whereby traditional methods of pedagogy and learning are rejected in favour of the new.
Table 1: Table displaying the attainment grouping of pupils who strongly agreed or agreed to usually finding practical activities more interesting and exciting.

<table>
<thead>
<tr>
<th>Class Set</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower set</td>
<td>2</td>
</tr>
<tr>
<td>Middle set</td>
<td>19</td>
</tr>
<tr>
<td>Rather not say</td>
<td>7</td>
</tr>
<tr>
<td>Top set</td>
<td>30</td>
</tr>
<tr>
<td>(blank)</td>
<td></td>
</tr>
<tr>
<td>Grand Total</td>
<td>59</td>
</tr>
</tbody>
</table>

Moreover, an analysis of co-variates revealed some correlation between attainment grouping and frequency of use of equipment. Table 2 displays a cross tabulation of these results. Pupils who were classified as top set expressed a greater preference in using practical resources. This result was puzzling at first, as children within this set utilised manipulatives least often. The subsequent segment discusses this outcome in significant depth. This result was interpreted as attributed to the culture of the classroom where the manipulatives were frequently encountered especially outside the remit of the mathematics lesson, yet rarely used. Also, whilst many of the children enjoyed the intrinsic experience of using manipulatives, referring to their use as ‘fun’ or ‘like playing with toys and games’ they questioned the efficacy particularly when learning mathematics.

Table 2: Table displaying the attainment grouping of pupils who strongly agreed/agreed they enjoyed using practical mathematical equipment during lessons.

<table>
<thead>
<tr>
<th>Class Set</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower set</td>
<td>3</td>
</tr>
<tr>
<td>Middle set</td>
<td>29</td>
</tr>
<tr>
<td>Rather not say</td>
<td>10</td>
</tr>
<tr>
<td>Top set</td>
<td>35</td>
</tr>
<tr>
<td>(blank)</td>
<td></td>
</tr>
<tr>
<td>Grand Total</td>
<td>77</td>
</tr>
</tbody>
</table>

Further, of the children surveyed, 72% indicated they felt regularly challenged to try new methods with the new resources, yet just over half the children surveyed acknowledged they understood how to use the equipment provided. As seen in the literature review, students’ success in the use of manipulatives were related to the teachers’ expertise. The research indicated the teacher
should develop knowledge of the full range of capabilities of each resource. Making use of manipulatives within lessons does not always make the process of teaching mathematics easier. Whilst mathematical manipulatives can provide a platform to support children to think more deeply about their learning, this is only achieved when modelled correctly. Few reports inform teachers how to integrate manipulatives successfully.

Despite this preference of using concrete manipulatives, 68.6% of the students surveyed were of the view that manipulatives added value to learning and aided them to achieving better results. These combined results are significant as they imply that, whilst children value the use of manipulatives, they are not always sure how to use them. This result is conclusive with Skemp (1977), Ball (1992) and Boulton-Lewis (1998)'s research that determines manipulatives are unable to carry meaning or insight and children must understand how to use the materials presented well enough to avoid using them in rote manner.

Additionally, the survey results demonstrated clear variations in the views held surrounding the receipt of the number of mathematics lessons per week (Table 1). The results should have been standardised due to national requirements. This discrepancy was attributed to attainment grouping. Some pupils participated in additional Booster sessions (additional lessons during playtime and after school) prior to sitting summative assessments. In focus groups the children reported to me the additional lessons’ impact on the views they have of mathematics and the use of manipulatives as these sessions are often offered at recreational times. Studies have determined grouping by attainment can prove detrimental to self-esteem (Ireson et al., 1999, Hallam et al., 2002, Taylor, 2016). Gamoran and Berends (1987), found grouping by ability/attainment not only has an adverse effect on children’s self-esteem, but also their self-concept and attitudes towards school work. Whilst it can be asserted that children should be provided with opportunities to work at a speed and level appropriate to their needs, attainment setting can force children to think about the differences in attainment and impact negatively on their overall progress.
Table 3: Table reporting number of mathematics lessons received per week.

<table>
<thead>
<tr>
<th>Number of lessons per week</th>
<th>Lower set</th>
<th>Middle set</th>
<th>Rather not say</th>
<th>Top set</th>
<th>(blank)</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-4</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>4-6</td>
<td>3</td>
<td>28</td>
<td>8</td>
<td>33</td>
<td>1</td>
<td>73</td>
</tr>
<tr>
<td>8-10</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>(blank)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>3</strong></td>
<td><strong>32</strong></td>
<td><strong>11</strong></td>
<td><strong>43</strong></td>
<td><strong>1</strong></td>
<td><strong>90</strong></td>
</tr>
</tbody>
</table>

Table 4: Table reporting teacher’s response to number of mathematics lessons received per week.

<table>
<thead>
<tr>
<th>Number of lessons per week</th>
<th>Teachers Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-4</td>
<td>1</td>
</tr>
<tr>
<td>4-6</td>
<td>4</td>
</tr>
<tr>
<td>8-10</td>
<td>2</td>
</tr>
<tr>
<td>(blank)</td>
<td>1</td>
</tr>
</tbody>
</table>

Memorable resource

Quantitative analysis of the open-ended responses revealed the students’ views of the manipulatives they least liked to use. The results indicated the protractor was least popular with children. Table 5 displays the results from the survey. Interestingly, the survey findings indicated the protractor was also the most memorable resource. Analysis of the data also revealed the resources the children would most like to learn how to use. It was difficult to determine the possible cause of this view solely from the survey findings alone.

Valid questions could be raised as to why some manipulatives are more memorable than others. It is difficult to determine from a survey alone if the protractor is more memorable than others simply because they are used most often or because of the level of difficulties experienced when used. Sousa (2015) contends human memory works by association, and thoughts trigger other memories stored within long-term memory. The brain’s ability to detect patterns is often referred to as ‘associative memory.’ (p39). Sousa goes on to explain how “whilst the associative memory is powerful, unfortunately it runs
into problems when various pieces of information must be kept from inferring with one another” (Sousa, 2015). When children are first introduced to the notion of using protractors, they may have few associated experiences to draw upon. Understanding how to use protractors correctly requires the learner to understand dual representation. DeLoache (2000) defines dual representation as the ability to “represent both the symbol (artefact) itself and its relation to its referent” (p.329). This can create a potential barrier where children struggle to develop this type of representational insight and verbalise their mathematical ideas. Opportunities should be made available for children to ask questions whilst they are developing their conceptual understanding.

Moreover, the experience of using protractors could be memorable because children are not resilient to failure. My experiences have suggested there exists a change in culture where children now expect immediate success and mistakes are no longer celebrated or tolerated within the context of the classroom. (Richardson et al., 1990) suggests that “resiliency is the process of coping with disruptive, stressful or challenging life events in a way that provides the individual with additional protective and coping skills than prior to the disruption that results from the event” (p34). However mistakes are part of the learning process and can be viewed as evidence of meaningful learning taking place (Hansen et al., 2014).

<table>
<thead>
<tr>
<th>Frequency of use</th>
<th>Children’s responses</th>
<th>Teachers Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everyday</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Once a week</td>
<td>40</td>
<td>1</td>
</tr>
<tr>
<td>Once a term</td>
<td>29</td>
<td>6</td>
</tr>
<tr>
<td>Never</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>86</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>

**Table 5: Tables reporting children’s and teacher’s response to the frequency of protractor use.**

**Controlled choice**

The graph below displays the findings of the least frequently used manipulatives. Notably, resources supporting the delivery of geometry and
measurement were less frequently used, with many of the participants indicating they rarely use geometric equipment at all (Figure b). Over 85% of the students surveyed indicated they have not used a geoboard. The researcher noted although lessons were planned for the systemic integration of a range of manipulatives to deliver geometry, this topic was often reserved to the end of term. Further, often planned lessons were interrupted or rescheduled due to wider curricular obligations. Pertinent questions could be raised as whether an imbalance still exists between the numerical coverage of the mathematical content of the curriculum in primary school in comparison with the geometric coverage, following the implementation of The National Numeracy Strategy DfEE (1999).

![Least Frequently Used Manipulatives](image1)
Figure 2: Students were asked to indicate how strongly they agreed to the statement 'I frequently use' for each resource. All participants indicated how strongly they agreed with the statement.

Approximately, 46% of the children surveyed disagreed that students should bring their own equipment to school, whilst surprisingly only 11% of students stated that they were encouraged to use their own equipment by teachers. This result indicates the children surveyed felt they do not have any measure of control in the spontaneous selection of manipulatives. Yet, Moyer and Jones (2004a) research details "spontaneous student choice where the children have access to them at their desk, permits students to devise their own solutions and strategies and promote autonomous thinking and confidence in the learning of mathematics" (p28).
Moreover, 45% were undecided if there were set rules on how to use the manipulatives and nearly half the children supported the view that they use a range of practical and online homework. Nevertheless, much of the homework set consisted of online content. It can be perceived that the homework set permitting few opportunities for concrete mathematical manipulatives to be utilised at home.

Yet, research conducted by Desforges and Abouchaar (2003) discusses the advantages of parental involvement especially during the primary phase. Nonetheless, there exist significant barriers to parental involvement especially in terms of using mathematical manipulatives. Parents may lack the confidence and the resources to adequately support their children with learning mathematics at home.

**Expectations of secondary school.**

Many the children surveyed expected mathematics lessons to become more challenging in secondary school with the introduction of new topics such as algebra.

The results of the surveyed also indicated the view that several of the children expected to encounter new manipulatives within secondary school such as the tangrams. Overwhelmingly, 77% of the children surveyed indicated that they expect to bring their own manipulatives to lessons in secondary school. This result could be ascribed to the conventions of the secondary classroom where manipulatives are not usually displayed.
Figure 3: Students were asked to indicate if they expected mathematics lesson to change or remain the same in secondary school.

The test question indicated a 98% response rate providing a strong indication that the responses provided were truthful and the anonymity afforded minimised compliance obedience.

4.2 Focus group interviews

All focus group interviews were transcribed and imported into Nvivo (qualitative analysis software) for thematic analysis. The data for the study was collected from four face-to-face focus group, semi-structured interviews with twelve participants in total. Each interview lasted approximately twenty minutes. The transcribed interviews provided an opportunity for the researcher to follow on and probe areas of interest discovered from the findings of the survey. The data collated was analysed using a thematic coding approach (Bryman, 2007). Braun and Clarke (2006) defines thematic analysis as the process of identification and recording of themes within the data and asserts “it is the first qualitative method of analysis that researchers should learn, as it provides core skills that will be useful for conducting many other forms of qualitative analysis” (2006).

Due to the flexibility associated with thematic analysis, it can be seen as essential to implement a systemised process to conduct and analyse the data.
Antaki et al. (2002) claims that in making use of clear and succinct guidelines with thematic analysis, means that the ‘anything goes’ critique of qualitative research is avoided. It also ensures an insightful representation of the data takes place. This systematic approach also covers how the analysis of the data took place, which is often missing from qualitative research (Antaki et al., 2002).

Therefore, following section details the systemised approach adopted of collation of data and the development of the thematic analytical framework adopted following the six phases of the thematic analysis listed in the Table 4.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Become acquainted with data</td>
<td>Transcribe data, read through the data repeatedly, noting initial nodes.</td>
</tr>
<tr>
<td>2. Create initial nodes</td>
<td>Identify interesting ‘basic’ nodes (level 1) in a systematic manner across the data set, classifying data relevant to each theme.</td>
</tr>
<tr>
<td>3. Identify themes</td>
<td>Arrange nodes into potential ‘organised’ themes (level 2), gathering all data relevant to each node. Run word frequency queries to identify unexpected themes from the data.</td>
</tr>
<tr>
<td>4. Review themes</td>
<td>Review data set again and identify parent nodes where possible. Create a thematic map of the analysis identifying interconnections between nodes.</td>
</tr>
<tr>
<td>5. Condense themes into major themes</td>
<td>Condense nodes into a ‘global’ theme (level 3), isolate significance of nodes (ongoing process of refining specific themes). Create clear definitions and titles for each theme.</td>
</tr>
<tr>
<td>6. Produce report</td>
<td>Select compelling extract examples for final analysis, relate back to research question and literature and produce well-defined and succinct report of analysis.</td>
</tr>
</tbody>
</table>

Summary of six phases of analysis Braun and Clarke (2006)
Phase 1 & 2: All semi structured focused group interviews were transcribed by the researcher. Although this process can be considered time consuming, it afforded the researcher with the opportunity to unearth basic themes salient to the overall text. Basic themes are considered ‘the lowest order’ and generally involves coding crucial points of interest that explains what is going on within the data (Attride-Stirling, 2001). Attride-Stirling (2001) recommend making use of three levels of organisation to locate within the text “explicit rationalisations and their implicated signification” (p.388). Afterwards an initial coding framework was devised of occurrences (Table 5).

Table 5: Initial coding framework

<table>
<thead>
<tr>
<th>Initial Analytical Framework</th>
<th>Number of Nodes</th>
<th>Number of Occurrences</th>
<th>Number of Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>All in my head</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Assignment to an attainment group/year group</td>
<td>2</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>Controlled use of manipulatives</td>
<td>4</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Feelings</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Helpful or useful resource</td>
<td>2</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Preferred practical resources</td>
<td>3</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Protractor</td>
<td>1</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Resources used at home</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Ruler</td>
<td>1</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Aid understanding</td>
<td>2</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Unfamiliar resources</td>
<td>4</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Virtual manipulatives.</td>
<td>2</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Expectations of secondary school</td>
<td>2</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Younger children</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
<td><strong>112</strong></td>
<td><strong>n/a</strong></td>
</tr>
</tbody>
</table>
**Phase 3:** This phase involved the organisation of basic themes related to a similar issue into cluster groups. These cluster groups are condensed and redefined (organised nodes). (Attride-Stirling, 2001) refers to ‘organised nodes’ as the middle stage (level 2) and asserts how, even though this stage is more abstract, it can be more revealing (refer to table 6). Robson (2011) asserts it is at this point the true process of interpretative analysis takes place and asserts thematic process is not linear, therefore much movement will take place. The researcher ran word frequency searches which revealed basic themes she had not previously identified. The results from word frequency searches caused some revisions to take place within the ‘organised’ nodes.

As this was the first time I had used QSR International Nivivo 11 software, this process became arduous. I was unfamiliar with the full range of components. Also, the software updated several times causing some ‘basic’ themes to be lost or duplicated. It was during this process that it became apparent the significance of maintaining ongoing memorandums as a record of retention and recall. This ongoing record allowed the researcher to track changes in thought and proved useful during the inscription process of the results.

Table 6: Condensing nodes into themes

<table>
<thead>
<tr>
<th>Organised Themes</th>
<th>Basic nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignment to an attainment group/ year group</td>
<td>Year group&lt;br&gt;Attainment group&lt;br&gt;Support group&lt;br&gt;Top set&lt;br&gt;Too smart&lt;br&gt;Younger children&lt;br&gt;Play&lt;br&gt;Helpful/useful&lt;br&gt;All in head</td>
</tr>
<tr>
<td>Memorable resources</td>
<td>Valuable resource&lt;br&gt;Aid understanding (dispenser of knowledge)&lt;br&gt;Symbolic&lt;br&gt;Protractors&lt;br&gt;Ruler&lt;br&gt;Preferred resource&lt;br&gt;Feelings&lt;br&gt;Learning</td>
</tr>
<tr>
<td>Controlled choice</td>
<td>Controlled use</td>
</tr>
</tbody>
</table>
Phase 4: The entire data set was reviewed again to identify if the initial hierarchal node system altered. The researcher also created a hierarchy Sunburst to compare with the organised themes identified (figure 4).

Phase 5 & 6: The ‘organised’ themes were refined further into a superior order. The final stage of isolating the ‘global’ theme proceeded. Attride-Stirling (2001) define the global stage as the point where the ‘principle metaphors’ are then identified. This technique permitted the research to obtain a holistic interpretation of children’s views from the data, and pinpoint compelling extract examples to include within the following succinct report.

**Assignment to an attainment group/ year group**

The children reported to me they were of the view concrete manipulatives should be used with younger children or as an aid to support children classified as lower attaining.

Table 7: Children’s views depicting the allocation of manipulatives
<table>
<thead>
<tr>
<th>Children's views regarding allocation</th>
<th>Number of occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attainment/year group</td>
<td>20</td>
</tr>
<tr>
<td>Specific references to children classified as the 'lower' attainment group.</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 7 illustrates the results. Concrete manipulatives should be predominantly used within Key stage 1 children was a common view held. The findings indicated year 6 children were of the view they were too smart to use manipulatives.

RESPONDENT 2: Yes, but they can be used for lower children in the school.
INTERVIEWER: As in younger children?
RESPONDENT 2: Yes

INTERVIEWER: how come you don’t use it? Why is it only set people in the class?
RESPONDENT 2: You know. We have different sets. Some people go to another classroom to do their maths in the morning. We separate for maths. So people in the other group will be doing it with base ten blocks but other people might be doing it with something else.

INTERVIEWER: Why do you think you do not use the abacus in your lesson?
RESPONDENT 3: It’s probably because we are too smart.

Furthermore, the data indicated there exists a solicited social stigma attached to the use of manipulatives, where usage indicated intellectual difficulties. This result coincided with the Ofsted (2012) publication, “Made to Measure,” findings of a greater use of concrete manipulatives in key stage 1 (children aged between 5-7) in comparison to key stage 2 (children aged between 7-11). This study also found concrete manipulatives were usually reserved as a teaching intervention to support the lowest performing pupils.

Yet Maccini and Hughes (2000) and Witzel et al. (2003) research concluded not only can concrete manipulatives be useful for the entire ability range, they can also be beneficial within secondary schools. Witzel et al. (2003) is cited suggesting “many students learning secondary-level maths benefited greatly from interacting with properly designed concrete materials” (p.50).
Moreover, the children expressed their concern over the efficacy of concrete manipulatives. Whilst they enjoyed using concrete manipulatives, they questioned the efficacy and likened their use to playing with toys.

RESPONDENT 2: Because it's more of a toy.
Reference 2: 2.16% coverage
INTERVIEWER: Do you think they are beneficial in year 6?
RESPONDENTS: No.
RESPONDENT 2: In reception, they use them as toys, they do not use them for learning.

This outcome corresponds with the literature questioning the efficacy of concrete manipulatives (McNeil and Jarvin, 2007, Moyer, 2001). McNeil and Jarvin (2007) research contends concrete manipulatives are counter intuitive. They further assert the process of utilising manipulatives can be cognitive challenging, inhibiting progress due to the requirement of dual representation (the object alone cannot be used as a symbol of a mathematical concept). They also asserted concrete manipulatives cannot be used in isolation.

Moyer (2001) research indicted the deployment in the use of manipulatives can also de-stabilise the efficacy of the resource, due to misuse within classrooms where they are often used as a source of amusement or reward and to add variety to the lesson. The teachers use of the term ‘fun’ can also inhibit perceived value. Moyer (2001) “because the use of the manipulatives was so often considered enjoyable by teachers and students, many of the teachers used the manipulatives as a privilege or reward for appropriate student behaviours” (p.186). As concrete manipulatives are tactile by nature and visual appealing their appearance can reinforcing the notion of play (Moyer, 2001).

RESPONDENT 3: At the beginning of year 6 we get to go into the ICT suite and play a maths game. And then they say they would be playing it in the classroom.

The children conveyed to the researcher they enjoyed using virtual manipulatives and were often provided with the opportunity to play online games once they had completed their mathematics lesson.

Memorable resources
The children’s descriptions revealed a relationship between the use of concrete manipulatives and the notion of intellectually understanding. The children asserted they were smarter if they no longer required the use of a manipulative. Once they knew how to understand mathematical concepts ‘in their head’ the manipulatives were no longer required. The term ‘in my head’ was indigenous typology related to abstract understanding.

INTERVIEWER: So, if you’re working on percentages of times tables you do not need to use any of those equipment at all? Why is that?
RESPONDENT 2: It’s all in my head.

Herts for Learning (2017) research into the use of concrete manipulative within primary schools’ findings support this notion, “the children liked to show that they could do things in their head (this was seen as a strength) rather than using ‘things’ to help them” (p.5).

Yet the literature has revealed concrete manipulatives are an important means of communication and non-communication, which can help scaffold abstract thinking. It is accepted that children will develop their abstract intellectual capacities through their interactions with concrete experiences. Yet, Skemp (1987) theories indicate although children’s early experiences with tactile resources can form the basis of later learning at an abstract level, he also discusses the significance of the construction of schemata (a cognitive framework that aids the organisation and interpret information). Schemas are used to connect what is already known to new learning. Whilst schemas can be useful as they permit shortcuts to made in the interpretation process of information, previous stages will be revisited. There exists a non-linearity to learning, a shifting backwards and forwards, especially when a concept is extended and connections are established. It is during this process that concrete manipulatives can be considered vital.

Furthermore, it is unclear from the children’s responses if the term “in my head” is ascribed to a lack of vocabulary to explain their ideas. Leibec
(1984) Experience, Language, Pictures, Symbols (ELPS) approach, associated with Bruner’s phases, accentuates the importance of children’s acquisition of the language of mathematics. She stresses the importance of not only the children learning the correct mathematical vocabulary, but also discusses the importance of the role of the teacher in extending the discussion (Leibeck, 1984). It was clear from the dialogue, that some of the children found the language aspect of mathematics to be less important than the ability to calculate. Furthermore, on occasions the associated mathematical language slowed down their ability to calculate.

**Controlled choice**

The children reported that they felt they did not have any measure of control in the spontaneous selection of manipulatives and they were often deployed by the teacher. Some of the children also reported that they were not always sure if the teacher knew how to make best use of the concrete manipulatives.

RESPONDENT 1: I think everyone should be able to use them because not everyone is the same. They might need it to work out something else. You might find it easier and sometimes you might find something else hard. You might use it (base ten blocks) for a different reason to someone else.

INTERVIEWER: Do you think the teacher should leave all resources out for you to pick whenever you need them?
RESPONDENT 1: I think that would be a good idea.

Much of the literature documents the significance of the role of the teacher in establishing quality classroom interactions, yet it can be extremely difficult for teachers to establish a balance between encouraging intellectual autonomy, and providing enough support to accomplish the desired outcomes of the lesson. Moyer and Jones (2004a) argue “sharing choice in the mathematical classroom implies that the teacher must give up some of the control of the learning to students thereby shifting their established roles as experts” (p.17). Many of the children expressed that they desired some autonomy in the accessibility and selection of manipulatives, in despite of the teachers responsibility to ensure progress is made. Yackel and Cobb (1996) research discusses the benefits attached to learning when teachers promote intellectual autonomy within a cohesive collaborative environment. This study details how the children within this study became active participants within the community of the classroom fostering what is described as progressive ethos.
Nonetheless, some of the children expressed concerns over the responsibility of complete democracy in the context of the classroom. Several children were of the view that they were not always sure how to best use the equipment and without the teacher’s direction they would be unsure what to learn. They also conveyed their concerns some children may play with the equipment instead of engaging in learning.

INTERVIEWER: Do you think you should have the equipment out for you to pick? For you to choose which ever equipment you want?
RESPONDENT 2: No because some people fiddle with it though out the whole lesson.
INTERVIEWER: So you think the teacher should always give you the set equipment?
RESPONDENTS: Yes.

Secondary school

Analysis of the data revealed the existence of some variation between views held, relating to expectations at secondary school. All children shared the view that mathematics lessons would change considerably. The majority of the children were of the view that they expected to use a wider range of manipulatives within secondary school. They also expressed the desire to use the equipment they had not yet encountered in secondary school. The children shared their excitement at the prospect of exploring the use of unfamiliar concrete manipulatives such as a compass and geoboard in secondary school. The children also conveyed their enthusiasm at the prospect of using the computer to learn mathematical concepts more often and independently.

RESPONDENT 3: I think we will use more skilled resources like the compass and the circle protractors and stuff like that.
RESPONDENT 2: We will use it (the computer) by ourselves.

The rest of the children were of the view that they no longer expected to use concrete manipulatives at all in secondary school.

RESPONDENT 2: In secondary they might think you like don’t need to use the equipment. Like you’ve already learned about things (in primary school). You won’t need to like use the protractor because you can use what you know in your head.

Following the transition to secondary school
The follow up interviews revealed few changes in the views held surrounding the use of mathematical manipulatives. The children reported, whilst they initially believed they would use a wider selection of manipulatives in secondary school, they had found they used them less.

RESPONDENT: I don’t think so. Basically, we use the same equipment but we do not use different equipment that much.

Many of the children reported that mathematics lessons had become significantly more challenging. Yet, even though the children reported they encountered manipulatives less frequently than they had experienced in primary school, they still were of the view they were valuable.

RESPONDENT: I still think they are useful but resources are like, it would be easier to using them but I still get on with my work with resources.

### 4.3 Observations - Vignettes

The second question of this study sought to capture the culture surrounding the deployment and use of manipulatives within primary classrooms. Two context rich vignettes capture the interactions in the one school classroom over two separate one-hour sessions. The researcher was imbedded in the research context to document the interactions between the children and the teacher when using manipulatives and, where possible, capture correlations between the views held and the use within the classroom.

The school observed was an inner London state primary school, with levels broadly in line with national averages. During the observed lesson, the four year 6 classes were streamed according to standardised summative assessments and attainment results. The group perceived as highest attaining (extension) were assigned to one of the deputy head teacher. The core group assigned to another teacher and the group assessed as achieving the lowest overall attainment (support group) were assigned to two teaching assistants. The lesson observed was related to the addition of two and three digit numbers as suggested in the National Curriculum in England, key stage 1 & 2, DfE (2013). The group assigned to the two teaching assistants were
selected for observation, as they were the only group making use of concrete manipulatives.

Vignette 1 – Dienes Block lesson

A range of the 3D shapes were displayed on the workstation next to the sink, lightly coated in dust, providing the finishing ornamental touches within the classroom. A container of multi-coloured multilink cubes and laminated number squares were stacked close by on a table.

The teaching assistant worked with small group of year 6 children (classified as lower ability) in the classroom whilst the rest of the class worked in two adjacent classrooms with the class teachers. She had a small easel whiteboard with whiteboard pens and the interactive white board was turned on with a PowerPoint presentation.

The nine children quickly settled into groups around the rectangular table in the centre of the classroom just in front the of the boards. Dienes blocks, pencils and maths books were placed on to the table in preparation for the lesson. In all there were three groups. The girls sat together and boys were seated at the adjacent side of the table.

The teaching assistant carefully recorded the first addition sum on to the easel board.

\[
\begin{array}{c}
7 & 9 \\
+ & 2 & 3 \\
\end{array}
\]
She inquired, ‘Do you know any method we can use to solve this sum?’
One of the boys reached out for the dienes blocks and proceeded to move
them together.

The teaching assistant scolded him sternly “Put them down! You must watch
what I am doing first!” She repeated the question again. A few hands went up
this time. She picked one of the girls who immediately responded
“Partitioning, we can partition.”

The teaching assistant responded, “Is that right?” A few children nodded in
agreement. She then reached out for the blue magnetic dienes blocks. She
pointed to 70 of the written figure 79 and asked, “How many tens do we have
here?” A few more hands went up this time. A girl responded “7.” The teaching
assistant promptly placed 7 blocks of ten on to the white board next to the
algorithm she had scribed. “How many units?” The same girl responded
again “9.” The teaching assistant praised her efforts and placed the 9
magnetic ones next to the tens. Thus, the magnetic dienes blocks were used
to partition the addend into tens and units. The same process was repeated
to demonstrate the partitioning of 23.

She questioned, “How do we find the total?” There were a few groans and
some of the children started mumbling together. The teaching assistant
responded “Come on. You should all be watching the board. How do we work
this out?” One of the boys put his hand up and was asked to come out to the
front. He proceeded to count all the units first.

He wrote on the board 12.

\[
\begin{array}{c}
    7 & 9 \\
    + & 2 & 3 \\
\end{array}
\]
The teaching assistant quizzed “Ah what do we have here then? Is he correct?” There were loud murmurs of disagreement and a few protests. One of the children suggested that he had not added all the tens.

At this point the teaching assistant moved from using the easel board to the interactive white board.

She explained, “Let us look at what each column represents. The children were prompted to recite with her “Units, tens and hundreds! So, what happens when our units are more than ten?” One of the girls put up their hand swiftly, then slowly put it back down again.

The teaching assistant used the interactive whiteboard to demonstrate the regrouping process. The 9 and 3 ones were exchanged for a 10 block and 2 units.

The children were instructed to replicate the process.
At first the children were eager to handle the manipulatives. One of the children struggled to group the Dienes blocks as shown. The teaching assistant took the remaining Dienes from his grasp and demonstrated the partitioning process again using the Dienes on the table this time. She asked “How do we partition 44 into tens and units? Look at the tens column. How many tens do we have here?”

While the manipulative used by the teaching assistant for modelling purposes appeared to resemble the resource handled by the children, there existed several dissimilarities. The magnetic Dienes were all blue in colour and were 2 dimensional, whereas the children used plastic 3D blocks in a variety of
different colours: the units were white, the tens were red, hundreds orange, and thousand blocks yellow.

**Analysis of vignette 1**

The vignette above provides an example of what Moyer and Jones (2004a) describes as control-orientated teaching. Control oriented teachers are described as educators who express power and influence through a variety of instructional behaviours (Moyer and Jones, 2004b). The control of the manipulative prominently remains at the teachers domain. Deci et al. (1982) is cited in Moyer and Jones (2004a) “If teachers are control-orientated the controlling aspects of their rewards or communications will likely be particularly salient, overshadowing and undermining children’s intrinsic motivations and perceived competence” (p.17). This type of interaction endorses a type of ‘essentialism’ in the use of concrete manipulatives in the primary classroom. Research has shown control-orientated teachers are more likely to criticise the children’s enactment and issue deadline statements or hints (Moyer and Jones, 2004b).

This finding correlated the students’ views shared during the interviews about their desire to have some autonomy over the choice of equipment they could use. Yet, the realities of teaching within a primary classroom environment is far more complex than simply handing over control of the learning process to the children. Whilst ideally control should be shared and children should be afforded the autonomy of choice when working with concrete manipulatives, the constraints of the rigid curriculum framework prevents this interchange from occurring. Pressure points in the system exists which impact on teaching and learning, particularly within year 6. Teachers are charged with the enormous task of ensuring all children make progress in terms of cognitive development whilst simultaneously ensuring they meet the statutory obligations of the mathematical curriculum. (Hansen et al., 2014) describes a comparable process of macro-level and micro level of development. The macro–level is defined as the teacher’s responsibility to meeting the statutory requirements whereas in contrast the micro level is related to the pressures
of accountability to personalise learning, respond to children’s needs and develop mathematical cognitive development. Hansen et al. (2014) is cited “this is challenging to do for even experienced teachers. It is challenging because the spiral curriculum we use presents mathematical concepts hierarchically and it presents conceptual development as a smooth progression throughout a child’s primary years” (p.1).

Furthermore, the teaching assistant who delivered the lesson was afforded very little preparation and planning time (5 minutes prior to the start of the lesson) to get to grips with the content of the lesson or manipulatives. Pajares (1992) demonstrates student achievement is correlated to the teachers’ experiences in using the manipulatives. Therefore, it is understandable for the teaching assistant to adopt a methodical approach to teaching when placed within in a pressured vulnerable position.

Moreover, the unskilled set of example questions contained on the worksheet did little to enhance cognitive development. The questions (figure 7) detailed identical sums with an unchanged level of difficulty. Should the children have trouble with the first example, then they were likely to experience similar strains throughout the lesson. The variation in colours and type of manipulatives used to model and deliver could have further added to the confusion. Koshy (2001) asserts misconceptions derive from an over reliance on the rules where either the child has not understood, forgotten or can only in part recall. Moyer and Jones (1998) studies assert manipulatives should in fact be used to assist the development of mathematical conceptual development and supplement instruction: “rather than teaching concepts, these “tools” may be used in more traditional ways, to teach algorithms, rules and procedures” (p2).

Significantly, it can be asserted that as the group requiring the most support, these students should have been taught by the teacher as opposed to the teaching assistant.
The Williams Review (2008) strongly recommended children who experienced difficulties with learning mathematics should receive one-to-one intervention from a qualified teacher. Dowker (2009)'s studies have proven that not only are targeted independent interventions beneficial, they can also have a significant impact on attainment. Yet, the reality is classroom teachers are driven by accountability measures of summative attainment results linked to performance targets, therefore will natural channel most of their energy to where they believe they can make can make the most impact. This action can downgrade the intrinsic value of the concrete manipulative and can leave the children within the support group feeling demoralised and unworthy, encouraging a culture within this group of obedience and compliance.

**Vignette 2 – Protractor lesson**

This subsequent lesson took place just after the year 6 SATs. All the year 6 children resumed their usual seated positions for this lesson and were not streamed. The teacher had differentiated photocopied worksheets and protractors prepared at the front of the classroom. On the interactive board displayed at the front of the class was a visual representation of a protractor.

![Figure 8: ITP (interactive teaching program) measuring angles (Primary National Strategy 2005)](image)

The teacher began the lesson with a brief demonstration of how to use visual representation of the protractor.
The teacher explained, “Today class we will be learning how to measure angles using a protractor.”

At this point, each child in the class was issued with a concrete protractor. As the protractors were distributed, the teacher briefly explained a protractor is simply a tool to help construct and measure angles.

The teacher resumed her position at the front of the classroom and asserted “All eyes on me! Please do not fiddle or touch the protractors until after I have shown you what to do.” Some children were praised for following this instruction.

Using the visual representation of the protractor, the teacher explained to the children how to locate the vertex point, located in lower middle section. She explained “What you must do is find the “upside-down T.” Once you have found this T slide your protractor to the vertex of the angle you are trying to measure. Find the end of the angle and then rotate the protractor so that the zero mark on the inside of the protractor is on top of one of the sides of the angle. The other side of the angle should be within the protractor.”

She them prompt the children to find the ‘upside down T.’

Figure 9: Illustration of the vertex point of the protractor (BBC, 2017)
Many the children struggled to locate the vertex point on the protractor. One of the children responded, “Miss, there is no ‘T’ on mine, just lots of numbers”. The teacher repeated her demonstration repeatedly asking questions such as, “Where do we start?” Should I start with my protractor this way up or this way up?

A boy put up his hand and responded, “We find the T first Miss, then look for the 0.”

The teacher praised his efforts yet appeared perplexed as to why so many of the class were experiencing such difficulty in locating the correct starting point. Most of the class where still frantically attempting to locate the ‘T.’

The teacher returned to her position at the front of the classroom and resumed, “Once you are able to measure your angle by locating the centre of your protractor, you should be able to read off the size of the angle. Remember, the side (line) of the angle should be ‘within’ the protractor. How is each scale numbered?”

One girl in the class responded, “In tens!”

The teacher praised her response and continued “Can anyone recall, what do we call an angle that measures exactly 180 degrees? What does this angle look like?”

Another child responded this time “A straight line, Miss.”

The teacher promptly completed the remainder of the demonstration. This involved subtracting the angle measured from 180, to determine the dimensions of the missing angle.
Flustered, the teacher promptly disseminated the worksheet (Figure 9) to the children who expressed they were confident in their use of the protractor. “Please make a start. Once you have finished, please complete the extension activity making sure you draw your angles accurately into your book.”

The children who could not locate the ‘T’ were asked to join the teacher at the front of the class. They were all issued the worksheet (figure 10) below.

Many the children who were allocated the worksheet with the photocopied protractors immediately abandoned the use of the concrete protractor. The class teacher spent much of the remainder of the lesson working closely with this group, visiting each child individually to demonstrate how to read the scale on the worksheet.

The children who had not experienced difficulties with the using the protractor experimented with creating a range of acute obtuse and reflex angles in
different orientations. Collaborative discussion took place between these children. One child explained “Wow! Look! You have drawn your angle this way and I have mine this way, yet they are both the same size.”

![Sample of the children's work.](image1)

There were just seven circular 360 degree protractors available. A few children, working on the independent extension task requested permission to make use of these protractors.

![Protractors used within lesson.](image2)

Once the lesson had concluded the protractors were collected and returned to the central resource cupboard.

**Analysis of vignette 2**

This vignette exhibits some of the complexities surrounding the use of static visual representations (type of virtual manipulative) as a teaching aid to
support the use of concrete equipment. Static visual representations are fundamentally visual images used on the interactive smart board. These images are designed to resemble the use of concrete manipulatives, however they cannot be flipped and turned in the same way (Moyer et al., 2015).

Whilst these visuals retain many useful properties, there are a few challenges that can result in children experiencing difficulties. The ITP protractor used on the interactive board was significantly larger. The upside down ‘T’ was much more visible to the naked eye, whereas in contrast, the concrete protractors used by the children were considerably smaller. Also, the static visual representation of the protractor could be manipulated in a completely different manner to the handheld prototype. I observed how visual representation of the protractor was configured in such a manner that when the teacher modelling the process of measuring the angle, the ray (portion of a line which starts at a point) was always clearly visible extending beyond the circumference of the protractor. Yet the teacher asked the children on several occasions to locate the angle within the protractor further adding to the confusion. The angles the children had to measure failed to extend in the same way. Some of the children struggled to read the increments within the confines of the protractor. Moyer and Jones (2004b) argues “the subtleties of how to use them (manipulatives) effectively or how students might use them are still not clearly understood” (p.16). I had the opportunity to work very closely with this teacher over the course of the study. It was evident from this vignette this teacher had abandoned the preferred method of teaching when pressured. Leibeck (1984) discusses ‘transmission’ theory centres around the teacher issuing precise instructions for the children to learn to use resulting in what Skemp (1977) describes as an instrumental approach to learning. Whilst there is a place for this approach to teaching, the prominence of verbal communication is lost. My observations indicated the teacher was usually hard-pressed to ensure all children make progress during the lesson. Instrumental approaches can provide quicker results for the teacher in the short term at the expense of verbal interaction. This can result in children leaving primary school without confidence and competence to explain their views (Askew, 2011). Children should be encouraged to
verbalise their ideas and opportunities should be made for them to ask and respond to open questions.

What is more, the worksheet encompassing the photocopied protractor resembled the visual representation with the extension of the ray and failed to provide the children with the opportunity to measure angles. The children were simply reading interval scales and were denied the opportunity to maneuver, discover or quantify the relative amount attributed to the angle.

Williams and Shuard (1994) discusses the complexities involved of measuring angles, and argues children must draw upon two diverse types of experiences (static and dynamic concept of angle) to gain a comprehensive understanding of the concept.

Additionally, the traditional dual scale used on the traditional protractor can be bewildering for children (Hansen et al., 2014). While some of the children had access to the 360 degree circular protractors with a pivot arm, there were not enough available for the entire class.

The children who were experiencing difficulties with the traditional protractors may have found the circular 360 degree protractors much simpler to use. Furthermore, the protractors could have been left out for the children to have some autonomy of choice and make use of them between lessons (Moyer and Jones, 2004b). Research conducted by Hirschhorn and Senk (1992) concluded pupils who were provided the autonomy of access to concrete manipulatives over used the tools initially, then developed a more composed approach overtime. Following the lesson, the teacher confirmed that the protractors were packed away as the school budget was limited and the protractors were required for examinations. Moyer and Jones (2004b) is cited “Accessing these tools is often claimed solely as the teacher’s domain” (p.17). Yet the reality, is there a multitude of possible explanations for the lack of use of concrete manipulatives, including the financial constraints of the school budget.
4.4 Practice implications

This study sought to capture the views of children. Dewey (1916) theorises and discusses the significance of the voice of the child during the teaching process, Article 12 (UNICEF, 2013) also endorses that children should be afforded the right to have their views taken in to consideration, especially when decisions are made that affect them. I believe that children’s views are still largely ignored in policy and practice. The children who participated in this study acknowledge the value of concrete manipulatives and enjoy using them, yet they expressed they feel they have a lack of autonomy in choice in making use of them. Ring (2016) argues “Listening and responding to the voices of children irrespective of age, or ability, enriches the learning and teaching process and supports both teacher and child-autonomy in an era where education is increasingly being driven by marketisation, standardisation and politicisation.”

Listening to children’s views can not only enhance self-esteem but can assisting the development of high-order thinking skill providing the children with a platform to verbalise, justify and explain their ideas and views (Ring, 2016). Most importantly, incorporating children’s views could enrich teaching and learning creating a positive experience for all.

The Department for Education (2016) has recently proposed an increase of £41 million of funding to primary schools to support the teaching of mathematics. Whilst this additional funding will prove useful, it does little to address the systemic failure which currently exists. This study has discovered there exists pressure points in the system. These pressure points significantly impact on the teaching and learning of mathematics and the views held surrounding the use of manipulatives.

Furthermore, the findings coincided with the literature. Mathematical manipulatives are not used as widely as they should be and are often reserved for the children classified as lower attainment group who are usually
taught by the teaching assistant. This downgrades their intrinsic value. This research discovered there is a veiled social stigma attached to the use of concrete manipulatives and some inequalities in the deployment and use of manipulatives. The findings uncovered some commonalities between children’s views of mathematical manipulatives, the deployment of manipulatives and Bourdieu (1986) theories of social capital. French theorist Bourdieu (1986) coined the concept of cultural capital. Cultural capital can be described as a type of cultural knowledge that serves to help children navigate the opportunities available within the context of the classroom and can alter the experiences and opportunities available. As the use of manipulatives are associated with intellectual difficulties, when used this reduces the individual’s worth or status within the context of the classroom. The use of the manipulatives can also restrict social mobility and can leave the individuals who rely on these resources feeling devalued and demotivated. The teacher unwittingly adds to this reduction in cultural capital by leaving the children who use these resources with the teaching assistant to be taught further reducing their currency within the culture of the classroom. This finding is worthy of further study.

This research has highlighted the role of the teacher is central to the deployment and use of manipulatives. The disparity in the use of using and applying resources would need to be explored in greater detail. The researcher will undertake further research into the current training requirements for prospective mathematics teachers and revised expectations for the delivery of the statutory syllabus to better understand if teachers are trained and encouraged to use a wide range of mathematics manipulatives to support delivery.

The results from the study also provided information of children’s preferences when learning mathematics. These findings can assist the researcher to devise and contribute to a more effective teacher-training programme. A summary of key findings was produced and presented to the University to which I am linked where it is expected the research will contribute and aid the development and revision of the PGCE (Postgraduate Certificate of
Education) mathematics modules of study. Yet, these findings alone are not helpful to the target population of teachers. Whilst I can endorse the importance of the heuristic and creative use of manipulatives, and promote the importance of linguistic opportunities; permitting children with some degree of choice in the manipulatives they use, it is not enough. Wilson (2012) *becoming a teacher involves more than just being ‘told what to do’ developing skills and mimicking other teachers*” (p.13).

Adults learn in a similar fashion to children. The moment teaching becomes prescriptive it seizes to be interesting at all. In providing opportunities for collaborative shared practice, more opportunities for the development of research and self-awareness without fear of failure, should enhance pedagogic practice. It can be claimed, as educators, the inclusion of children’s views should remain a priority to enable all invested to appreciate and enjoy the aesthetic aims of mathematics.

### 4.5 Limitations of study

As I was employed within the setting, questions could be raised surrounding the authenticity of the views shared and if the views shared were reflective of all participants. However, by exerting the ‘insider’ approach the children were more comfortable with working with me. I established trust and the usual social interactions were retained, thus providing a wealth of knowledge an outsider would not be privy to (Tedlock, 2000). The children talked more freely and openly enabling an insightful overview to be drawn.

Participants who provided consent were also afforded the right to withdraw at any given time. Whilst the withdrawal from quantitative research can bias the results, ethical integrity was maintained. No children exercised this right.

The triangulated method proved overly ambitious for me as an inexperience researcher. Also, the methods exerted were not as detailed and rigorous as I had initially set out for them to be. During the analysis, I noted the survey
could have been refined further in order that correlations could identified and between views held and frequency of use of equipment. Correspondingly, surveys cannot follow trends over time. It would have been useful if a follow up survey was carried out with participants once they had made the transition to secondary school. The timing of the IFS submission limited the possibility of conducting observations of lessons in secondary school. This additional data could have proved insightful.

The research findings may not be reflective of all schools. Some schools do not stream (assigning children with comparable skills and need into classes or groups) and engage in deploying manipulatives in a more inclusive manner regularly. Further research would need to be conducted within the field yet still, some insightful generalisations can be drawn.

Chapter 5: Conclusion

This study examined children’s views of mathematical manipulatives prior to, and following, the transition from primary to secondary. The usual customs surrounding deployment and use of manipulatives within the primary classroom were also of interest.

The results of this study indicate manipulatives are not used as widely as recommended in the research literature or the mastery policy. Although recently, there has been a push towards the use of manipulatives in primary schools they are failing to be used as widely and creatively as they could be.

This research discovered there is the existence of a veiled socialised stigma attached to manipulatives. The children who participated within this study associated the use of these apparatus with younger children or to support children with perceived intellectual difficulties. Children acknowledge the value of concrete manipulatives and enjoy using them, yet they expressed they feel they have a lack of autonomy in choice.
Many factors influence children’s views. The role of teacher has been highlighted as one of the most powerful influences of all. How the teacher deploys and refers to the mathematical manipulatives can significantly impact on children’s views relating to their use. In this study, teachers usually reserved the use of manipulatives for children classified as lower ability, which can downgrade their intrinsic value. There exist pressure points in the system, which impact significantly on learning. These pressure points can restrict the choice and range of manipulatives used, and the instructional behaviours adopted by the teacher. This finding coincided with the literature.

Furthermore, this research also revealed that children were of the view there existed some disparity in the use of resources. The children indicated they had not yet had the opportunity to make use of a range of geometric manipulatives. It was observed that this could be attributed to the timetabling of the mathematical curriculum where number and place value is often taught first and geometry left until the end of term.

The children anticipated they would encounter a range of new mathematical manipulatives once they reached secondary school and were excited at the prospect of using virtual manipulatives more often. The follow-up interviews concluded although they were now finding mathematics more challenging, they were no longer encountering the use of all manipulatives as often as they had in primary school.

Manipulatives provide children with the opportunity to creatively explore, and unpick the newly acquired knowledge, and when utilised appropriately can provide the platform to enhance linguistic capabilities and aesthetic aims of mathematics. Furthermore, they provide the time for practice and consolidation of mathematical knowledge. Should the teacher fail to influence children positively in the use of manipulatives, it can have a detrimental impact.
This study has gone some way to report and identify children’s views and identify factors impacting on the views held, but there is still plenty of scope for further research and analysis. This research is framed in the view that learning is not a ‘linear’ process and the constructivist learning environment should have a specific goal that is not overtly structured. Furthermore, epistemology can be viewed as a shifting process as opposed to a concrete phenomenon due to the ongoing development of empirical knowledge founded upon the individual experiences. This in turn suggests that irrespective of age or attainment all children can benefit from the use of the full range of manipulatives when making sense of emerging mathematical ideas.

The researcher’s role was not simply to provide a platform for children to communicate; it was to discover the unique contribution of children’s experiences in order that decisions can be made with their best interests at heart. Children are not passive recipients of education and their views matter. Furthermore, children’s views form not only their current experiences, but can impact have a lasting for the future. If teachers are to aspire children to hold positive views of mathematical manipulatives, then change must start with the experiences teachers provide for children when learning mathematics.

Words: 18347
Appendix 1

https://docs.google.com/forms/d/1cwkZBzEc8VoBdjcKVW9L-oT0-rSi7206UwrvJalMytw/edit?usp=sharing
https://docs.google.com/forms/d/1E-KHnUva13DqwWtbiJMceSLObSoYko0Rm26vqtn1wys/edit?usp=sharing

Appendix 2

Semi Structured Interview Questions

Research Questions

1) What are secondary school children’s views on using mathematical manipulatives?
2) How do secondary children describe their use of mathematical manipulatives?

- When we carried out the survey we found out most children stated that they least liked to use________. What do you think of that?
- How often do you use________ in class?
- Do you prefer to use practical resources or online resources? Why?
How would you describe your experiences of using mathematical resources?

Do you find them useful/helpful? Why?

Which resources do you least like to use? Why?

Can you pick which resources you use?

Could you talk me through how the teachers uses ______ in class?

Are there any resources that you find difficult to use? Why?

Are there any ways in which we can make them easier for you to use?

Do you feel these resources help you learn mathematics better?

If you could plan your own ideal mathematics lessons using any resources you like, which resources would you select? Why?

Appendix 3

A Study of Children’s Views of Mathematical Manipulatives in the Transition from Primary to Secondary

A research project

Start date: March 2016
End date: February 2017

You are invited to take part in a mathematics research project. The aim of this research is to explore children’s views towards the mathematical equipment you use.
Your views and opinions are important and central to all the decisions we make as teachers to ensure you achieve the very best during your time in school.

This study will ask you how you and your classmates feel about the mathematics equipment you use during lessons. This information will help us develop better resources and lessons.

Whatever answers you provide during the group discussion will be kept anonymous. This means that we will not be able to link what you say to your name. Your parents and teachers know that you are being asked to take part, but they will not see your answers. However, if you decide on your own to give us information other than what we have asked for, and we are worried that you or someone else may not be safe, we might have to tell someone.

In either case, the questions should not be too difficult and we do not expect that they will upset you. However, if you find that you are struggling with the questions for any reason you can ask for help.

Appendix 4

Child Consent form

A Study of Children’s Views of Mathematical Manipulatives in the Transition from Primary to Secondary

Start date: March 2016
End date: February 2017

I agree to take part in the Mathematical Research Project
and I would like to take part in a group discussion.  

☐ (please tick)

I have read and understood the information leaflet. I know what the study is about and the part I will be involved in. I know that I do not have to answer all of the questions and that I can decide not to continue at any time.

If you do want to take part, please sign your name below:

Signed: ……………………………………………………………

Date: ………………………..
“A Study of Children’s Views of Mathematical Manipulatives in the Transition from Primary to Secondary.”

PARENT PARTICIPANT INFORMATION SHEET

Your child has been invited to take part in a mathematics research project. Please read this information sheet carefully before deciding whether or not to allow your child to participate. Your child is not obliged to take part in this research and they do not have to provide a reason if they do not wish to take part. If they decided to take part, they are free to change their mind and withdraw from the research at any time without reason.

What is the purpose of the study?
This study aims to record and report the culture surrounding the use of mathematical manipulatives within two year 6 classrooms prior to, and following the transition from primary to secondary. Manipulatives are resources teachers use to aid and engage students in their learning. In primary school, concrete manipulatives such as Dienes blocks are commonly used, however by the time children reach secondary school the use of concrete manipulatives appears to give way to more virtual and computer based tools. This study seeks to examine school children’s views of both types of manipulatives in terms of ‘usefulness’ to their learning experience. Children’s views and opinions are important and central to all the decisions we make as teachers to ensure they achieve the very best during their time in school.

This research project will ask your child how they feel about the mathematics equipment they use during lessons. This information will help teachers to develop better resources and lessons. Having as many young people as participate will help us do a better job!
Consent form for parents/carers

A Study of Children’s Views of Mathematical Manipulatives in the Transition from Primary to Secondary

Start date: March 2016
End date: February 2017

Please complete this form after you have read the Participant Information sheet explaining the research.

1) I agree for my child to take part in the above study.

2) I confirm that I have read and understand the Participant Information Sheet. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

3) I understand that my child’s participation is voluntary and that they are free to withdraw at any time, without giving reason.

4) I agree that the researcher will contact my child again in year 7 to continue to participate in the research.

If you are willing for your child to take part, please sign your name below:

Signed: ……………………………………………………………

Date: ……………………………
Your Child’s name:

..............................................................................................

Your name:

..............................................................................................

Your email address:

..............................................................................................

Your Address:

..............................................................................................
..............................................................................................
..............................................................................................

Contact No:

Home..............................................................................................

Mobile..............................................................................................
Secondary school for Year 7:

.................................................................
APPENDIX 7

“A Study of Children’s Views of Mathematical Manipulatives in the Transition from Primary to Secondary.”

TEACHER PARTICIPANT INFORMATION SHEET

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. You are not obliged to take part in this research and you do not have to give a reason if you do not wish to take part. If you decided to take part, you are free to change your mind and withdraw from the research at any time without reason. If you do choose to withdraw from the research, your relationship with the researcher will not be affected in any way.

What is the purpose of the study?
This study aims to record and report the culture surrounding the use of mathematical manipulatives within two year 6 classrooms prior to, and following the transition from primary to secondary. Manipulatives are resources teachers use to aid and engage students in their learning. In primary school, concrete manipulatives such as Dienes blocks are commonly used, however by the time children reach secondary school the use of concrete manipulatives appears to give way to more virtual and computer based tools. This study seeks to examine school children’s views of both types of manipulatives in terms of ‘usefulness’ to their learning experience.

While there is a large body of literature on the utility of manipulatives to learning, there exists a need to better understand the students view concerning the use of both concrete and virtual forms. Understanding pupil’s views could help educators craft more effective and tailored mathematics curricula.
Why I have been invited to participate? What are the benefits?
Understanding pupil’s perceptions could help educators craft more effective and tailored mathematics curricula, improve the quality of instruction and assist children achieve their full potential.

What will happen to me if I take part and what would I have to do?
You will be asked to complete a short online survey, assist your students complete an online survey and allow me to observe in the classroom.

What are the possible disadvantages and risks of taking part?
There are no disadvantages associated with taking part in the study. It can in fact enhance your professional practice.

Will my taking part in the study be kept confidential?
I will keep a record of your name, age, sex and results of the study in a record that will be stored on a password protected computer to ensure only persons involved in the study can access them. The storage of your data is compliant with the Data Protection Act 1998. All information that is collected about you during the course of the research will be kept strictly confidential. Any information about you will have your personal information removed so that you cannot be recognised from it. All data will be stored for a maximum of 5 years, and will not be released without written permission from yourself or unless required by law.

What will happen to the results of the research study?
Data from the completed study will be analysed and any results may be published in educational journals and/or present the research findings at relevant educational conferences. I will be happy to provide you with a copy of your personal results from the study on request if you wish, and a copy of the completed study.

What do I do next?
If you have any questions about the study, please contact me Syreeta Charles-Cole (s.cole.14@ucl.ac.uk). If you have read and understood this information sheet, any questions you had have been answered, and you would like to be a participant in the study, please now see the consent form.

Thank you for considering to take part in the study and for taking the time to read this information sheet.
This research investigation has been granted full ethical approval by the UCL Institute of Education Department of Education Research Ethics Committee (BERA) Approval FIRE
Appendix 8

Consent form for class teacher

A Study of Children’s Views of Mathematical Manipulatives in the Transition from Primary to Secondary

Start date: March 2016
End date: February 2017

Please complete this form after you have read the Participant Information sheet explaining the research.

5) I agree to take part in the above study.

6) I confirm that I have read and understand the Participant Information Sheet. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

7) I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason.

If you do wish to take part, please sign your name below:

Signed: ……………………………………………………………

Date: ……………………………
Your Name:

.................................................................

Your email address:

.................................................................
Appendix 9

Ethics Application Form: Student Research

All research activity conducted under the auspices of the Institute by staff, students or visitors, where the research involves human participants or the use of data collected from human participants are required to gain ethical approval before starting. *This includes preliminary and pilot studies.* Please answer all relevant questions responses in terms that can be understood by a lay person and note your form may be returned if incomplete.

For further support and guidance please see accompanying guidelines and the Ethics Review Procedures for Student Research [http://www.ioe.ac.uk/studentethics/] or contact your supervisor or researchethics@ioe.ac.uk.

**Before completing this form you will need to discuss your proposal fully with your supervisor(s).**

Please attach all supporting documents and letters.

*For all Psychology students, this form should be completed with reference to the British Psychological Society (BPS) Code of Human Research Ethics and Code of Ethics and Conduct.*

<table>
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<tr>
<th>Section 1  Project details</th>
<th>A Study of Children’s Views of Mathematical Manipulatives in the Transition from Primary to Secondary</th>
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<tr>
<td>a. Project title</td>
<td></td>
</tr>
<tr>
<td>b. Student name and ID number (e.g. ABC12345678)</td>
<td>Syreeta Charles-Cole CHA07053656</td>
</tr>
<tr>
<td>c. Supervisor/Personal Tutor</td>
<td>Dr Melissa Rodd/ Cathy Smith</td>
</tr>
<tr>
<td>d. Department</td>
<td>Faculty of Education</td>
</tr>
<tr>
<td>e. Course category (Tick one)</td>
<td>PhD/MPhil                                              EdD</td>
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<td>MRes                                                   DEdPsy</td>
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<td>MTeach                                                 MA/MSc</td>
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</table>
Diploma (state which) [ ]
Other (state which) [ ]

f. Course/module title Institute Focused Study (IFS)
g. If applicable, state who the funder is and if funding has been confirmed.
h. Intended research start date February 2016
i. Intended research end date February 2017

j. Country fieldwork will be conducted in
   If research to be conducted abroad please check www.fco.gov.uk and submit a completed travel insurance form to Serena Ezra (s.ezra@ucl.ac.uk) in UCL Finance (see guidelines). This form can be found here (you will need your UCL login details available): https://www.ucl.ac.uk/finance/secure/fin_acc/insurance.htm
   UK

k. Has this project been considered by another (external) Research Ethics Committee?
   Yes [ ]
   No [ ] go to Section 2

   External Committee Name:
   Date of Approval:

   Yes:
   - Submit a copy of the approval letter with this application.
   - Proceed to Section 10 Attachments.

   Note: Ensure that you check the guidelines carefully as research with some participants will require ethical approval from a different ethics committee such as the National Research Ethics Service (NRES) or Social Care Research Ethics Committee (SCREC). In addition, if your research is based in another institution then you may be required to apply to their research ethics committee.

Section 2 Project summary

Research methods (tick all that apply)

Please attach questionnaires, visual methods and schedules for interviews (even in draft form).

- Interviews
- Focus groups
- Questionnaires
- Action research
- Observation
- Controlled trial/other intervention study
- Use of personal records
- Systematic review ⇒ if only method used go to Section 5.
- Secondary data analysis ⇒ if secondary analysis used go to Section 6.
- Advisory/consultation/collaborative groups
Please provide an overview of your research. This should include some or all of the following: purpose of the research, aims, main research questions, research design, participants, sampling, your method of data collection (e.g., observations, interviews, questionnaires, etc.) and kind of questions that will be asked, reporting and dissemination (typically 300-500 words).

A Study of Children’s Views of Mathematical Manipulatives in the Transition from Primary to Secondary

The Institute Focused Study (IFS) aims to record and report the culture surrounding the use of mathematical manipulatives within two year 6 classrooms prior to, and following the transition from primary to secondary. Manipulatives are resources teachers use to aid and engage students in their learning. In primary school, concrete manipulatives such as Dienes blocks are commonly used, however by the time children reach secondary school the use of concrete manipulatives appears to give way to more virtual and computer based tools. This study seeks to examine school children’s views of both types of manipulatives in terms of ‘usefulness’ to their learning experience.

While there is a large body of literature on the utility of manipulatives to learning, there exists a need to better understand the students view concerning the use of both concrete and virtual forms. Understanding pupil’s views could help educators craft more effective and tailored mathematics curricula.

Study Aims

Specifically, it aims to:

(1) describe the culture in primary schools surrounding the use of manipulatives.

(2) record and report children’s views towards mathematics manipulatives prior to, and following the transition from primary to secondary.

Research question:-

1) What is the culture in primary schools surrounding the use of manipulatives?

2) How do children describe their use of mathematical manipulatives in the transition from primary to secondary?

Participants and sampling:
This overt ethnographic study will be conducted using a mixed method approach, involving a range of methodological tools to record the students’ view. The researcher will be working within the school setting for six months and aspires to gain a deeper understanding of the culture surrounding the use of manipulatives, provide the foundation for future studies. In this instance, the methods employed include an online attitudes survey, semi-structured focused group interviews and classroom observations. The aim is to derive a range of data sources to construct a detailed picture of the children’s views surrounding the use of manipulatives within the settings.

Data collection will involve a purposeful sample across two research sites. An appropriate number of students will participate across both sites, four classes, mixed ability sets, totalling 120+ students. The survey sample will be aged between 10-11 and distributed online. A five point Likert scale will be used, with a few questions included requiring the respondent to produce a more reflective response. The year 6 teachers (4 in total) will also complete the survey. Direct classroom observations will be carried out in all four classes and photographs taken of the resources used.

Semi-structured focus group interviews will be recorded using a table top Dictaphone in conjunction with scribed notes. This will provide participants the opportunity to reflect upon their responses provided in the survey, as well as assist the researcher to follow up the participants’ responses. The focus group interviews will be conducted in groups of 3 with a minimum of 12 volunteers.

**Data Collection**

Data will be analysed using thematic review and factor analysis in order that themes correlations and inter correlations can be identified.

**Reporting and dissemination**

Prior to dissemination, all participants will be informed of how the data will be used (see attached information sheet). An anonymised summary of findings will be circulated directly to the schools.

The reported key findings will be presented to the University to which I am linked where the research will contribute and aid to the development and revision of the mathematics modules.

**Section 3 Participants**

Please answer the following questions giving full details where necessary. Text boxes will expand for your responses.

a. Will your research involve human participants?  
   Yes ☑ No ☐ go to Section 4

b. Who are the participants (i.e. what sorts of people will be involved)? Tick all that
**apply.**

**Children**

<p>| | |</p>
<table>
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<tr>
<td></td>
<td>Early years/pre-school</td>
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<tr>
<td>X</td>
<td>Ages 5-11</td>
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<tr>
<td>X</td>
<td>Ages 12-16</td>
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<td></td>
<td>Young people aged 17-18</td>
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<td></td>
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<td>Adults please specify below</td>
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<td>Other – specify below</td>
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</table>

**NB:** Ensure that you check the **guidelines** (Section 1) carefully as research with some participants will require ethical approval from a different ethics committee such as the National Research Ethics Service (NRES).

N/A

c. If participants are under the responsibility of others (such as parents, teachers or medical staff) how do you intend to obtain permission to approach the participants to take part in the study?

*(Please attach approach letters or details of permission procedures – see Section 9 Attachments.)*

Consent form

d. How will participants be recruited (identified and approached)?

The gatekeeper will select the classes who will participate in the study. Focus group interviews will be conducted with a random selection of willing participants. All volunteers will be provided the opportunity to participate.

e. Describe the process you will use to inform participants about what you are doing.

An information sheet and consent form will be issued to all participants in line with the schools policy.

f. How will you obtain the consent of participants? Will this be written? How will it be made clear to participants that they may withdraw consent to participate at any time?

*See the guidelines for information on opt-in and opt-out procedures. Please note that the method of consent should be appropriate to the research and fully explained.*

Please see attached consent form

h. **Studies involving questionnaires:** Will participants be given the option of omitting questions they do not wish to answer?

Yes  ☒ No ☐

If NO please explain why below and ensure that you cover any ethical issues arising from this in section 8.

**Studies involving observation:** Confirm whether participants will be asked for
their informed consent to be observed.

Yes ☒ No ☐

If **NO** read the guidelines (Ethical Issues section) and explain why below and ensure that you cover any ethical issues arising from this in section 8.

<table>
<thead>
<tr>
<th>i.</th>
<th>Might participants experience anxiety, discomfort or embarrassment as a result of your study?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>☐ No ☒</td>
</tr>
</tbody>
</table>

If **yes** what steps will you take to explain and minimise this?
If **not**, explain how you can be sure that no discomfort or embarrassment will arise?

<table>
<thead>
<tr>
<th>j.</th>
<th>Will your project involve deliberately misleading participants (deception) in any way?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>☐ No ☒</td>
</tr>
</tbody>
</table>

If **YES** please provide further details below and ensure that you cover any ethical issues arising from this in section 8.

<table>
<thead>
<tr>
<th>k.</th>
<th>Will you debrief participants at the end of their participation (i.e. give them a brief explanation of the study)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>☒ No ☐</td>
</tr>
</tbody>
</table>

If **NO** please explain why below and ensure that you cover any ethical issues arising from this in section 8.

<table>
<thead>
<tr>
<th>l.</th>
<th>Will participants be given information about the findings of your study? (This could be a brief summary of your findings in general; it is not the same as an individual debriefing.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>☒ No ☐</td>
</tr>
</tbody>
</table>

If **no**, why not?

---

**Section 4 Security-sensitive material**

*Only complete if applicable*

Security sensitive research includes: commissioned by the military; commissioned under an EU security call; involves the acquisition of security clearances; concerns terrorist or extreme groups.

<table>
<thead>
<tr>
<th>a.</th>
<th>Will your project consider or encounter security-sensitive material?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>☐ * No ☒</td>
</tr>
</tbody>
</table>
Section 5 Systematic review of research  
Only complete if applicable

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Will you be collecting any new data from participants?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Will you be analysing any secondary data?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Give further details in Section 8 Ethical Issues

If your methods do not involve engagement with participants (e.g. systematic review, literature review) and if you have answered No to both questions, please go to Section 10 Attachments.

Section 6 Secondary data analysis  Complete for all secondary analysis

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Name of dataset/s</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>b. Owner of dataset/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Are the data in the public domain?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* If no, do you have the owner’s permission/license?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Are the data anonymised?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Do you plan to anonymise the data?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Do you plan to use individual level data?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Will you be linking data to individuals?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Are the data sensitive (DPA 1998 definition)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Will you be conducting analysis within the remit it was originally collected for?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. If no, was consent gained from participants for subsequent/future analysis?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. If no, was data collected prior to ethics approval process?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Give further details in Section 8 Ethical Issues

If secondary analysis is only method used and no answers with asterisks are ticked, go to Section 9 Attachments.
Section 7 Data Storage and Security

Please ensure that you include all hard and electronic data when completing this section.

| a. Confirm that all personal data will be stored and processed in compliance with the Data Protection Act 1998 (DPA 1998). (See the Guidelines and the Institute’s Data Protection & Records Management Policy for more detail.) | Yes ✗ |
| b. Will personal data be processed or be sent outside the European Economic Area? | Yes ☐ * No ✗ |

* If yes, please confirm that there are adequate levels of protections in compliance with the DPA 1998 and state what these arrangements are below.

N/A

| c. Who will have access to the data and personal information, including advisory/consultation groups and during transcription? N/A |
| d. Where will the data be stored? Cloud storage and laptop (password encrypted). |
| e. Will mobile devices such as USB storage and laptops be used? * If yes, state what mobile devices: * If yes, will they be encrypted?: yes |

| f. Where will the data be stored? As above |
| g. How long will the data and records by kept for and in what format? All survey-generated data will record as an Excel spread sheet. Interview data will be stored on NVivo All data will be stored until my doctorate is completed (over 5 years). |
| h. Will data be archived for use by other researchers? * If yes, please provide details. |

Section 8 Ethical issues

Are there particular features of the proposed work which may raise ethical concerns or add to the complexity of ethical decision making? If so, please outline how you will deal with these.

It is important that you demonstrate your awareness of potential risks or harm that may arise as a result of your research. You should then demonstrate that you have considered ways to minimise the likelihood and impact of each potential harm that you have identified. Please be as specific as possible in describing the ethical issues you will have to address. Please consider / address ALL issues that may apply. 

*Ethical concerns may include, but not be limited to, the following areas:

- Methods
- Sampling
- Recruitment
- Gatekeepers
- Informed consent
- International research
- Risks to participants and/or researchers
- Confidentiality/Anonymity
- Disclosures/limits to confidentiality
- Data storage and security both during and after
1. Risks to participants
   - Conforming testimony: Unequal power relationships and how to counter the perceived unequal relationship between an adult researcher and child participants.
   - Confidentiality and anonymity.

2. Documenting students' views of teachers' practice
   - Ethics surrounding the documenting students' views of teachers' practice.
   - Power relations between the teacher and researcher.

3. Gatekeeper issues
   - Refusal of access.

4. Methods
   - Administration of the survey can impact on valuable teacher-directed time or break times, which could pose a risk to participants.
   - Observations - consent
   - Focus group - consent

5. Data storage and security
   - Online survey material/ transcripts/scribed notes from interview/observation.

6. Participation Selection
   - Understanding and Informed Consent.

These are the steps I plan to take in order to address the issues highlighted above:

1. Risk to participants
   - Article 3 of the United Conventions of the Rights of Children (ENCRC) requires that all actions concerning children should be made in the best interests of the child, and their needs given primary consideration. The Children Act (2012) enforces that children should be consulted about matters that affect them. All children who participate within the study will be provided with access to an information sheet detailing the study. I endeavour to work closely with the gatekeepers to discuss the requirements in relation to the information sheet (eg access restricted to the class teacher to read out or for distribution to each child) and the procedures for consent in line with the schools policy. Participants will be informed of their right to opt out at any stage. The class teacher will also have access to the survey prior to administration. If required, the parents/carers of the participants involved within the interview will be provided with an information sheet and consent forms. Children will be afforded with the right to be accompanied during the interview should they wish. Every effort will be taken to avoid bias of reporting.

   - The UNCRC also recognises the tension between children’s rights to protection and the right to participation. Article 12 of the UNCRC requires
that all children who are capable of forming their own views should be granted the right to express their views freely in all matters affecting them, commensurate with their age and maturity. This pilot study permits children to take advantage of this right with the support of their class teacher and parents/carers. An information sheet will be provided to facilitate their informed assent based upon understanding.

- Children may not be used to expressing their views freely or being taken seriously by adults because of their position in an adult-dominated society. In order to overcome this challenge of how best to enable children to express their views, the survey will be completed anonymously online in order to minimise compliance obedience or harm caused by the intrusion of the collection of data. The follow up interviews will be conducted with a small sample. I do not expect my research to raise sensitive material, however as a precaution the information sheet states that the researcher might not be able to guarantee complete anonymity should children disclose a safeguarding issue that impacts on the safety and well-being of the participants. All participants are afforded the right to refrain from responding to any questions without penalisation such they feel the questions posed are of a sensitive nature (eg ability set). I endeavour to comply with safeguarding procedures in line with current best practice. The identity of participants will not be disclosed and all issues related to confidentiality in line with the BERA guidance and Data Protection Act (1998).

- This pilot study acknowledges the importance of children’s contribution where their feedback will contribute to the final design.

- In addition, the information sheet states participants should provide full and honest answers in order to eliminate a conforming testimony.

2. Documenting students' views of teachers' practice
   - All information discussed during the focus group interviews will be kept anonymous and confidential. The class teachers will receive a summary of findings.
   - The relationship between the teacher and the researcher will not be affected in any way as a consequence of the study.

3. Gatekeeper issues
   - I will liaise closely with all gatekeepers in order to facilitate access to the research participants. A number of schools have already preliminary agreed to participate within this study. I hold a valid and up to date Disclosure and Barring Service (DBS) certificate.

4. Methods
   - In accordance with the rules of consequentialism, the researcher will form a partnership with the gatekeeper of the school to ensure that completing the survey will not impact on the participants allocated study time. In order to minimise disruption, interviews will be conducted at the school at a time that is suitable for the children.
   - Ethnography involves the study of people in their natural setting, using methods of data collection to capture ordinary activity. The researcher will
provide as much information as possible to ensure of participants informed consent, however there will be no specific moment of choice as to whether or not they are involved during the classroom observation. The focus will be on the use of manipulatives.
- All participants will provide consent prior to participating in the focus group interviews.

5. Data storage and security
- I will follow the British Education Research Association (BERA) written guidance on good practice when storing data. The online survey results are cloud encrypted with private access (restricted to my supervisor and I). All data from the survey and interviews will be anonymised with the allocation of codes and password encrypted.

All participants and parents/carers will be debriefed following the collection of the data in order to ensure that the participants have not been adversely affected. It will also provide the opportunity for the participants to reflect upon their contributions, ask questions, as well as be thanked for their contribution.

6. Participation Selection
- Focus group interviews will be conducted with a selection of willing participants. All participants who have provided consent will be included irrespective of gender, race or perceived ability.

Information sheets and consent form will be provided to all participants and their parents/carers in line with the schools’ policy. Participants who provide consent will have the right to withdraw at any given time and I will comply with any requests following withdrawal including the deletion of data if requested. Whilst I remain mindful that the withdrawal from quantitative research can bias the results, I will maintain my ethical integrity.

Section 9 Further information
Outline any other information you feel relevant to this submission, using a separate sheet or attachments if necessary.
Link to online survey (draft format):

**Online Survey**

[https://docs.google.com/forms/d/1cwkZBzEc8VoBdjcKVW9L-oT0-rSi7206UwrvJalMytw/edit?usp=sharing](https://docs.google.com/forms/d/1cwkZBzEc8VoBdjcKVW9L-oT0-rSi7206UwrvJalMytw/edit?usp=sharing)

[https://docs.google.com/forms/d/1E-KHnUva13DqwWtbijMceSLObSoYko0Rm26vqtn1wys/edit?usp=sharing](https://docs.google.com/forms/d/1E-KHnUva13DqwWtbijMceSLObSoYko0Rm26vqtn1wys/edit?usp=sharing)

<table>
<thead>
<tr>
<th><strong>Section 10</strong> Attachments Please attach the following items to this form, or explain if not attached</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Information sheets and other materials to be used to inform potential participants about the research, including approach letters</td>
</tr>
<tr>
<td>b. Consent form</td>
</tr>
</tbody>
</table>

**If applicable:**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>c. The proposal for the project</td>
</tr>
<tr>
<td>d. Approval letter from external Research Ethics Committee</td>
</tr>
<tr>
<td>e. Full risk assessment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Section 11</strong> Declaration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes ☒ No ☐</td>
</tr>
</tbody>
</table>

I have read, understood and will abide by the following set of guidelines.

BPS ☒ BERA ☒ BSA ☐ Other (please state) ☐

I have discussed the ethical issues relating to my research with my supervisor.

I have attended the appropriate ethics training provided by my course.

**I confirm that to the best of my knowledge:**

The above information is correct and that this is a full description of the ethics issues that may arise in the course of this project.
Please submit your completed ethics forms to your supervisor.

Notes and references
Professional code of ethics

Disclosure and Barring Service checks
If you are planning to carry out research in regulated Education environments such as Schools, or if your research will bring you into contact with children and young people (under the age of 18), you will need to have a Disclosure and Barring Service (DBS) CHECK, before you start. The DBS was previously known as the Criminal Records Bureau (CRB). If you do not already hold a current DBS check, and have not registered with the DBS update service, you will need to obtain one through at IOE. Further information can be found at http://www.ioe.ac.uk/studentInformation/documents/DBS_Guidance_1415.pdf

Ensure that you apply for the DBS check in plenty of time as will take around 4 weeks, though can take longer depending on the circumstances.

Further references
The www.ethicsguidebook.ac.uk website is very useful for assisting you to think through the ethical issues arising from your project.


Wiles, R. (2013) What are Qualitative Research Ethics? Bloomsbury. A useful and short text covering areas including informed consent, approaches to research ethics including examples of ethical dilemmas.

Departmental use
If a project raises particularly challenging ethics issues, or a more detailed review would be appropriate, you may refer the application to the Research Ethics and
Governance Administrator (via researchethics@ioe.ac.uk) so that it can be submitted to the Research Ethics Committee for consideration. A Research Ethics Committee Chair, ethics representatives in your department and the research ethics coordinator can advise you, either to support your review process, or help decide whether an application should be referred to the Research Ethics Committee.

Also see’ when to pass a student ethics review up to the Research Ethics Committee’: [http://www.ioe.ac.uk/about/policiesProcedures/42253.html](http://www.ioe.ac.uk/about/policiesProcedures/42253.html)

<table>
<thead>
<tr>
<th>Reviewer 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisor name</td>
<td>Melissa Rodd/Cathy Smith</td>
</tr>
<tr>
<td>Supervisor comments</td>
<td>The ethical considerations have been carefully thought through.</td>
</tr>
<tr>
<td>Supervisor signature</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reviewer 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Advisory committee/course team member name</td>
<td>Cathy Smith</td>
</tr>
<tr>
<td>Advisory committee/course team member comments</td>
<td></td>
</tr>
<tr>
<td>Advisory committee/course team member signature</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decision</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Date decision was made</td>
<td></td>
</tr>
<tr>
<td>Decision</td>
<td>Approved</td>
</tr>
<tr>
<td></td>
<td>Referred back to applicant and supervisor</td>
</tr>
<tr>
<td></td>
<td>Referred to REC for review</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Recording</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Recorded in the student information system</td>
<td></td>
</tr>
</tbody>
</table>

Once completed and approved, please send this form and associated documents to the relevant programme administrator to record on the student information system and to securely store.
Further guidance on ethical issues can be found on the IOE website at [http://www.ioe.ac.uk/ethics/](http://www.ioe.ac.uk/ethics/) and www.ethicsguidebook.ac.uk
Appendix 10

95 responses

Summary

Age
- 11
- 10
- 9

Ethnicity

- Asian: 4 (4.4%)
- Black: 50 (54.9%)
- Chinese: 0 (0%)
- White: 21 (23.1%)
- Mixed: 11 (12.1%)
- Prefer not to say: 5 (5.3%)

Class Set

- Top set: 43 (48.3%)
- Middle set: 32 (36%)
- Lower set: 3 (3.4%)
- Rather not say: 11 (12.4%)

https://docs.google.com/forms/d/1E-kl8n3vJal37DwWmZwS2iEL083YkeXklHui26vqu1wQ/viewanalytics
Gender

- Boy: 46 (51.1%)
- Girl: 44 (48.9%)

Number of mathematics lessons per week

- 2-4: 8 (9.2%)
- 4-6: 73 (83.9%)
- 8-10: 6 (6.9%)

Protractor

I regularly use a protractor

- Strongly agree: 15 (17.2%)
- Agree: 44 (50.6%)
- Neither agree or disagree: 18 (20.7%)
- Disagree: 5 (5.7%)
- Strongly disagree: 5 (5.7%)

Protractor - Frequency of use

- Every day: 13 (15.1%)
- Once a week: 40 (46.5%)
- Once a term: 29 (33.7%)
- Never: 4 (4.7%)

https://docs.google.com/forms/d/1E-KHluva3JQswWbh2Mec6LO6sYu0IRm2qoqlaYrs/viewanalytics

2/26
**Mathematics Equipment Survey**

- **Compasses**
  - Strongly agree: 3 (3.4%)
  - Agree: 12 (13.6%)
  - Neither agree or disagree: 8 (9.1%)
  - Disagree: 0 (0%)
  - Strongly disagree: 15 (17.2%)

- **Set Square**
  - Strongly agree: 3 (3.4%)
  - Agree: 12 (13.6%)
  - Neither agree or disagree: 8 (9.1%)
  - Disagree: 24 (27.6%)
  - Strongly disagree: 31 (35.6%)

- **Frequency of use**
  - Every day: 0 (0%)
  - Once a week: 10 (11.8%)
  - Once a term: 24 (28.2%)
  - Never: 51 (60%)

---

https://docs.google.com/forms/d/1E-KHnUva33J0wpW6bi6L06bTOYoYzuORIt3bq5Oy3/viewanalytics
Set square - Frequency of use

- Every day: 2 (2.3%)
- Once a week: 9 (10.5%)
- Once a term: 14 (16.3%)
- Never: 61 (70.9%)

Calculator

I regularly use a calculator

- Strongly agree: 27 (31.4%)
- Agree: 27 (31.4%)
- Neither agree nor disagree: 16 (18.6%)
- Disagree: 9 (10.5%)
- Strongly disagree: 7 (8.1%)

Calculator - Frequency of use

- Every day: 17 (20%)
- Once a week: 21 (24.7%)
- Once a term: 35 (41.2%)
- Never: 12 (14.1%)

Unifix

I regularly use unifix

https://docs.google.com/forms/d/1E-KHnUa13QqW6hiLO65oYk0Rm2fOqtmIwys/viewanalytics
Strongly agree 5 5.8%
Agree 25 29.1%
Neither agree or disagree 26 30.2%
Disagree 9 10.5%
Strongly disagree 21 24.4%

Unifix - Frequency of use

Every day 5 5.7%
Once a week 15 17.2%
Once a term 36 41.4%
Never 31 35.6%

Base Ten Blocks

I regularly use base ten blocks

Strongly agree 13 14.9%
Agree 19 21.8%
Neither agree or disagree 22 25.3%
Disagree 17 19.5%
Strongly disagree 16 18.4%

Base ten blocks - Frequency of use

Every day 6 7%
Once a week 14 16.3%

https://docs.google.com/forms/d/1E-KHnmUa13DqwWb6bMce5L0t6oYt26tmfqumv5ays/viewanalytics
Dice

I regularly use dice

<table>
<thead>
<tr>
<th>Opinion</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>17</td>
<td>19.5%</td>
</tr>
<tr>
<td>Agree</td>
<td>22</td>
<td>25.3%</td>
</tr>
<tr>
<td>Neither agree or disagree</td>
<td>29</td>
<td>33.3%</td>
</tr>
<tr>
<td>Disagree</td>
<td>12</td>
<td>13.8%</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>7</td>
<td>8%</td>
</tr>
</tbody>
</table>

Dice - Frequency of use

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every day</td>
<td>6</td>
<td>7.1%</td>
</tr>
<tr>
<td>Once a week</td>
<td>15</td>
<td>17.6%</td>
</tr>
<tr>
<td>Once a term</td>
<td>52</td>
<td>61.2%</td>
</tr>
<tr>
<td>Never</td>
<td>12</td>
<td>14.1%</td>
</tr>
</tbody>
</table>

Geoboard

I regularly use a geoboard

<table>
<thead>
<tr>
<th>Opinion</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>23</td>
<td>7%</td>
</tr>
<tr>
<td>Agree</td>
<td>37</td>
<td>23.3%</td>
</tr>
<tr>
<td>Neither agree or disagree</td>
<td>44</td>
<td>57%</td>
</tr>
<tr>
<td>Disagree</td>
<td>12</td>
<td>7%</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>7</td>
<td>22.3%</td>
</tr>
</tbody>
</table>
Strongly agree 1 1.2%
Agree 6 7%
Neither agree or disagree 10 11.6%
Disagree 20 23.3%
Strongly disagree 49 57%

Geoboard - Frequency of use

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Count</th>
<th>Percentage</th>
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<tr>
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<tr>
<td>Once a week</td>
<td>5</td>
<td>5.9%</td>
</tr>
<tr>
<td>Once a term</td>
<td>7</td>
<td>8.2%</td>
</tr>
<tr>
<td>Never</td>
<td>73</td>
<td>85.9%</td>
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Abacus

I regularly use an abacus

<table>
<thead>
<tr>
<th>Opinion</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>7</td>
<td>8.1%</td>
</tr>
<tr>
<td>Agree</td>
<td>10</td>
<td>11.6%</td>
</tr>
<tr>
<td>Neither agree or disagree</td>
<td>8</td>
<td>9.3%</td>
</tr>
<tr>
<td>Disagree</td>
<td>22</td>
<td>25.6%</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>39</td>
<td>45.3%</td>
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</table>

Abacus - Frequency of use

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every day</td>
<td>5</td>
<td>5.8%</td>
</tr>
<tr>
<td>Once a week</td>
<td>6</td>
<td>7%</td>
</tr>
<tr>
<td>Once a term</td>
<td>11</td>
<td>12.8%</td>
</tr>
<tr>
<td>Never</td>
<td>64</td>
<td>74.4%</td>
</tr>
</tbody>
</table>
Tangrams

I regularly use tangrams

- Strongly agree: 3 (3.5%)
- Agree: 5 (5.8%)
- Neither agree or disagree: 15 (17.4%)
- Disagree: 21 (24.4%)
- Strongly disagree: 42 (48.8%)

Tangrams - Frequency of use

- Every day: 0 (0%)
- Once a week: 5 (5.9%)
- Once a term: 15 (17.6%)
- Never: 65 (76.5%)

3d Nets

I regularly use 3d Nets

- Strongly agree: 11 (13.3%)
- Agree: 40 (48.2%)
- Neither agree or disagree: 21 (25.3%)
- Disagree: 6 (7.2%)
- Strongly disagree: 5 (6%)

https://docs.google.com/forms/d/1E-KHnUva13QpsWb6h5Mc4L06sYoYx0Rm2bqsmv/t/viewanalytics
3d Nets - Frequency of use

- Every day: 5, 5.9%
- Once a week: 9, 10.6%
- Once a term: 61, 71.8%
- Never: 10, 11.8%

Numberline

I regularly use numberlines

- Strongly agree: 28, 32.6%
- Agree: 32, 37.2%
- Neither agree or disagree: 15, 17.4%
- Disagree: 5, 5.8%
- Strongly disagree: 6, 7%

Numberline - Frequency of use

- Every day: 18, 21.7%
- Once a week: 29, 34.9%
- Once a term: 29, 34.9%
- Never: 7, 8.4%

Cuisenaire Rods

I regularly use cuisenaire rod
Strongly agree 81 94.2%
Agree 3 3.5%
Neither agree or disagree 1 1.2%
Disagree 1 1.2%
Strongly disagree 0 0%

Ruler - Frequency of use

Every day 84 97.7%
Once a week 1 1.2%
Once a term 0 0%
Never 1 1.2%
I regularly use online mathematical games

- Strongly agree: 14, 16.3%
- Agree: 26, 30.2%
- Neither agree or disagree: 15, 17.4%
- Disagree: 16, 18.6%
- Strongly disagree: 15, 17.4%

Online mathematical games - Frequency of use

- Every day: 11, 12.9%
- Once a week: 23, 27.1%
- Once a term: 21, 24.7%
- Never: 30, 35.3%

I like using mathematical equipment during lessons.

- Strongly agree: 47, 56.6%
- Agree: 31, 37.3%
- Neither agree or disagree: 5, 6%
Using practical equipment makes maths lessons more fun.

- Strongly agree 27 (31.8%)
- Agree 37 (43.5%)
- Neither agree or disagree 13 (15.3%)
- Disagree 7 (8.2%)
- Strongly disagree 1 (1.2%)

Using online mathematical equipment makes lessons more fun.

- Strongly agree 20 (23.8%)
- Agree 37 (43.5%)
- Neither agree or disagree 20 (23.8%)
- Disagree 6 (7.1%)
- Strongly disagree 1 (1.2%)

I like to choose which mathematical equipment to use.

- Strongly agree 25 (29.8%)

https://docs.google.com/forms/d/1E-KH0Vuax13DsQwW3ls2MeLyLO6t0YX0t0f6m2vqtn1wys/viewanalytics
110

I usually find practical mathematical activities more interesting and exciting.

I am encouraged by my teachers to use whichever equipment I choose.

Mathematical equipment/resources are valuable learning tools.

https://docs.google.com/forms/d/1EKhUnua13DpsWbsh2Mce5LOhsoYko6Mz2xemv1wys/viewanalytics
The mathematical equipment available helps me to learn more advanced mathematics.

Strongly agree 32 37.2%
Agree 38 44.2%
Neither agree or disagree 14 16.3%
Disagree 1 1.2%
Strongly disagree 1 1.2%

I regularly feel challenged to try new methods when presented with new resources/equipment.

Strongly agree 20 23.3%
Agree 44 51.2%
Neither agree or disagree 14 16.3%
Disagree 5 5.8%
Strongly disagree 3 3.5%

The use of mathematical equipment helps me understand new concepts more easily.

Strongly agree 24 28.9%
Agree 36 43.4%
Neither agree or disagree 16 19.3%
Disagree 6 7.2%
Strongly disagree 1 1.2%
I achieve better results when using mathematical equipment.

Strongly agree 14 16.3%
Agree 45 52.3%
Neither agree or disagree 17 19.6%
Disagree 8 9.3%
Strongly disagree 2 2.3%

I always know how to use the equipment I am provided.

Strongly agree 28 32.9%
Agree 25 29.4%
Neither agree or disagree 24 28.2%
Disagree 6 7.1%
Strongly disagree 2 2.4%

I have access to a wide range of mathematical resources.

https://docs.google.com/forms/d/1E-KHuUt/a13QwW6u23c5fLO06oYr00Rm2tvqmnw/viewanalytics
Strongly agree 19 23.5%
Agree 32 39.5%
Neither agree or disagree 23 28.4%
Disagree 5 6.2%
Strongly disagree 2 2.5%

There are no set rules on how to use mathematical resources.

Strongly agree 4 4.9%
Agree 19 23.2%
Neither agree or disagree 40 48.8%
Disagree 13 15.9%
Strongly disagree 6 7.3%

I use a range of both practical and online mathematical resources to complete my homework.

Strongly agree 7 8.5%
Agree 33 40.2%
Neither agree or disagree 24 29.3%
Disagree 11 13.4%
Strongly disagree 7 8.5%
I use a range of both practical and online mathematical resources.

Strongly agree 9 11%
Agree 34 41.5%
Neither agree or disagree 22 26.8%
Disagree 11 13.4%
Strongly disagree 6 7.3%

Pupils should bring their own mathematical equipment to lessons.

Strongly agree 13 15.7%
Agree 11 13.3%
Neither agree or disagree 21 25.3%
Disagree 14 16.9%
Strongly disagree 24 28.9%

I bring my own mathematical equipment to lessons.

Strongly agree 3 3.6%
Agree 6 7.1%
Neither agree or disagree 10 11.9%
Disagree 30 35.7%

https://docs.google.com/forms/d/1E-KHkUxa1oIDqWbicMR6oL6b0eYn6OBlM2rsvqM1wys/viewanalytics
If you could plan your own perfect mathematics lesson which equipment would you use? Why?

I would use a protractor because it is fun using it.

compasses because we dont use them.

compasses weve never used them

ruler protractor

ruler cause for straight lines.

I would use a compass because they engage people since they are fun to use.

Protractor because im not use to using them.

Compasses because it will be fun for all the students and will know how to make or design pie charts.

Ruler because you need it to be precise with your measurement.

I would use a compass because it helps you learn how to make a decent circle

I would use a protractor because im not used to using other equipment.

im not quiet sure.

I will use a protractor and do angles.

protractors and ruler because those equipment are easy and simple to use.

i would do different things and use my equipment because it is easy to use.

I would use a ruler so my lesson would be 2d shapes.

I would use protractors to mesure angles

3D shape because I ILIKE it all the time and it help me to know diffrrent shape.

I would use unifix because it helps me so I would think that it would help others like it helped me.

I would use a protractor ruler and mirror.Becoues it helps me more.
I would use a protractor because I love measuring angles and it helps me to understand more about acute, obtuse and reflex angles.

I would use a protractor in lessons because they are fun to use and measuring angles is a good maths activity.

A protractor because you could know more about acute, reflex and obtuse angles.

It would be protractor because I am not good at using it.

A ruler because it is very useful in lessons and you could draw any shapes whatever you like.

Calculator to help us understand questions more.

A calculator so I can see if I got the answers correct.

3d shape net and rulers

Ruler

ruler to help me to mesure things
everything because its much more easier.

i would use a protractor to measure angles and estimate them.

A ruler A calculator A set Square and a compass

Compass; to draw circles, rulers; for straight lines and measurements and protractor; for measuring angles.

it depends what lesson we are doing.

it depends what lesson we are doing

It depends what lesson it is.

A ruler, a calculator, a set square, compass and a numberline.

Protractor: because I have learnt to use it thoroughly throughout the year and I am confident in using it. Ruler: because it helps build precision in writing and it adds a maths feel into any type of lesson eg. numbers

I would use like to be taught how to use a Compos accurately

i would use protractors and more complicated things because it would help us in secondary school.

I would use a protractor, a ruler, a pencil, a block of cubes and a kumpas because I really like maths.

I would use protractors for measuring and I would use unfix for counting and subtracting.

a protractor because its very fun and challenging when you use it for the first time

a ruler because its easy to use.

i would use a ruler a number line pencil a calculator a base of ten blocks to count and the understand the question

protractors rulers and pencils.

I would use ruler

Online mathematics

A ruler. Because I like to measure things and see the cm of objects.

unicons, because they always help me when I struggle in maths

I would use online equipment because it helps me and I am sure other students understand better.
I would use dice because they are fun depending on how you use them. I chose dice because they are simple to use.

I would use number lines, blocks and online games because they are fun.

I would use a protractor because I do lots of angles.

I would use a protractor so that we could find the angle of shapes.

I would use a pencil to write a ruler to measure stuff also to underline and a rubber to rub out any mistakes.

I would use protractors and rulers because if angle questions come up in a test they can understand how to solve it.

I would use rulers protractors and many more because I would do statistics.

Because I love geometry I would use protractor, 3D nets, tangrams and geoboard.

I would use calculators because if there is a question you are really stuck on you can simply use a calculator.

I would use a protractor as it is helps us understand angles.

I would use a ruler because it is easy.

If I was planning a lesson based on negative numbers, I would use a number line because it is very visual and has helped me a lot throughout my school.

I would use a protractor if I was to measure angles and a compass to draw a circle which is very helpful.

A compass and protractor because they can be confusing.

I would use a ruler so children can learn how to measure better.

Rulers, protractors and things such as numicon and blocks because they are easy to use and help.

I would use cubs because you can do lots of things with it like division multiplication, addition and subtraction.

I would use a protractor because some people struggle to use a protractor and its helps because in your SATs you would use a protractor to solve the missing angles.

I would use mathematical games because that helps you to know what your doing and if you don’t understand something it can help you and teach you stuff that you don’t know so that your more confident doing it.

I would use a protractor because you would use it to measure angles to find out how many degrees it is.

I would use the Cuisenaire rods because it helps me to understand things in maths more and how much of something is there it really helped me with ratio.

I would use 3D shapes and 2D shapes.

I would use a Protractor because, it's quite complex, teaching people how to use a Protractor and I like challenges. Also, learning how to use a Protractor would massively help in measuring angles (unless you're not meant to measure the angles), instead of doing really complex maths to work out an exact angle, you could just use a Protractor.

I would start with using a ruler to draw a margin in the book and get set on a lesson and use range of mathematical equipment like: a protractor for measuring angles; calculator to help...
us with calculating answers ......

Which resources do you least like using? Why?

a compass because I barely use it.
numicon because it is confusing
numereon as its a bit confusing
compass. Because it's hard to do a perfect circle with it.
protractor.
I don't like using cubes because they don't help me.
Ruler cause its the most common thing and it gets me bored.
I don't like using cubes because they do not help me with my work and they are very confusing.
protractors because they sometimes get me stuck.
I don't know
ruels because I hate measuring.
numerocs because its very difficult to use.
one of them.
mirror because I've never gotten used to using it and I prefer dotting and lining up the shape myself.
protractors because I can't measure angles correctly.
I least like compasses because their hard yo use
Ruler because I can know inches and points all the time.
The base ten blocks because it does not help me and I don't understand how to use it.
I least like using a compass because it is not very useful to make circles.
Nothing
A compass because you don't really need to make your circles neat and not that useful.
protractor because I not good at using it.
Protractor because it takes along time to work the degree out.
compass because I can never make a perfect circle!
protractor and ruler, because I like to calculate degrees.
numeर
Protractor
ruel to help me to mesure things
ruel because when I am doing cm or m I use them a lot.
Tan-grams, compasses and abacusses
A set square a compass
Abacus; because I feel that they are not very useful, or at least for me it is.
I hate using compasses.
i hate using compasses
Tan-grams and abacusses.
A protractor because im not always sure on which side to use.
Compass: because it makes me struggle more with circles and makes everything harder. Also I prick my fingers when I use it because its sharp.

Tan-grams and cuisenaire rods

A ruler because I'm not quite accurate

I least like using measuring cups because they are sometimes hard to use.

I least like using a compass because it is hard to use.

I least like using a protractor because sometimes they aren't exact. And a compass because they are hard to use.

I least like using abacus because it doesn't make maths more fun.

I don't prefer any resources over each other

I like all resources

I don't like using a compass because it is hard to use.

I don't like using protractors because sometimes they aren't exact. And a compass because they are hard to use.

I don't like using base ten blocks because its hard to tell which number it is.

I like all of the equipment's used.

I don't like to use a protractor because sometimes it gets confusing.

I least like using a protractor because sometimes they aren't exact. And a compass because they are hard to use.

I least like using a compass because it is hard to use.

I don't prefer any resources over each other

I least like using a protractor because sometimes they aren't exact. And a compass because they are hard to use.

I like all of them because its fun using them all.

I like all of the equipment that is provided because it is really helpful.

I like all of them because its fun using them all.

I don't like to use a compass because, it's quite irritating when you have to hold it down with one hand and turn it round to make a circle with the other.
The mathematical resource I least like using is 3d nets because we can make our own nets and whatever shape we want.

Do you expect your maths lesson in secondary school to

<table>
<thead>
<tr>
<th>remain the same</th>
<th>change</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>67</td>
</tr>
<tr>
<td>20.7%</td>
<td>81.7%</td>
</tr>
</tbody>
</table>

How do you expect your lessons to change?

Because there going to be harder.
It would change as the maths would get more advanced.
we would learn more complicated things.
Secondary will teach us much more complicated algebra.
we would learn different things but they are harder
I expect to be more harder.
im not sure.
I think it'll be a lot more complicated and hard.
harder things to do.
Harder questions.
i won't to learn other thing how to do a+a like that.
They will be more challenging.
a bit harder.
More activities and the math equations become more difficult.
I expect the lessons to become more challenging.
More activities and useful maths equipment.
I want the maths to go harder.
To get harder and more challenging.
It will be harder.
I think it would become harder.
to key stage two status
because your in a different school
because ppl are dumb and ppl are smart so they have to make them different coz plus they change every year and the smart/dumb ppl are not equaly the same.
by making it more easier.
It s going to be harder.
I expect it to be more difficult and challenging, or at least give us different work compared to the maths lessons in primary school.
I will expect it to change because whilst people grow up they learn different things. 
Be more fun and engaged using resources that we haven't previously used in primary schools. Have a fun feeling in the learning.
i expect them to be a bit more difficult and challenging.
I expect them to be more challenging.
they should change by getting harder
they will get harder.
because i am getting older and i need a more challenging task
because I will be older and we will learn more things that are complicated
To be more harder than it is now.
because i need to learn new things to achieve better work
To get harder and more advanced also challenging for me.
Because they're going to have new tools to help me with my work
because everything will get harder and harder.
I expect them to be a lot more harder
In secondary school we will get big number .
by doing more harder stuff.
Because in year 6 we only write in our books but in year 7 I think that we will use more adult equipment.
more harder work
By using new equipment ; I want it to be hard so it is a challenge.
Because in Secondary the work is a lot harder and different from primary work, so I guess it will change because of what set you are in.
They will change as we will have to learn more harder mathematical ways to solve a problem.
they would have more equipments.
I expect them to be more challenging.
Because they will get harder and use more advanced items.
because we will be learning new things.
I think they will be more active and engaging but also require more work.
because it will get a bit tricky and we will be new to new maths equipment.
because in primary the work is easy and I want to be successful so I want harder work
I think maybe it will change and get harder because were growing more and more and our brain develops more and more to fill in all the extra stuff that I don't really know. It will change because we will be starting and moving onto better and harder things.
I would like it to change so that I could learn new things.
because secondary is a lot different and some of the things not used here we will use in secondary.
They will become more complicated as it is secondary school.
I expect them to change in a way that, they get a lot harder and more complex. Not just doing simple sums such as 4 X 19 (column method), but doing more complex sums such as equations.
In primary the lessons are the same but in different year groups the sessions get harder each time but in secondary school it is going to be completely different because the sessions are
going to change and get even more extreme

**Do you expect to bring your own mathematical equipment to lessons in secondary school?**

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>19</td>
<td>23.2%</td>
</tr>
</tbody>
</table>

Optional comments/Feedback

I can't wait for SECENDARY!!!
Because you in order for you to do revision you should have your own equipment
Because the equipment to be there.
nothing to say.
I think maths will be harder in and different subjects so I'll try my best and aim high.
I like some time because not fun now .
I don't enjoy maths very much because there are too much calculations to solve in one equation.
Nothing
I really enjoy maths, it is my best subject because I really like calculations and it is useful in peoples daily life.
I expect to bring your own maths equipment because sometimes the equipment's break or not enough for us.
No
A good school should provide he children with equipment which lets their mind relax about not losing their pens and cases. Also people may bully each other on the colour of the cases and the brand e.g., Nike Adidas Jordan and many more.
yes because i am more responsible and able too bring my own equipment
I loved this survey it was so exiting!
I love that we get to find new things and fun facts about maths.
This was nice and relaxing
I want to use more resources.
it is very good
I find the maths equipment really helpful to me . But you don't have to use it all the time.
using equipment helps me but sometimes i don't use them
using equipment is helpful to me sometimes because sometimes feel it does not help at all but is just there but sometimes it helps.
I think that its really helpful to use maths equipment because it helps me learn more.
I really like to use the maths equipment but some time we don't need to use it

Number of daily responses

https://docs.google.com/forms/d/1E-KHluva13DqsWbshOmc6LO6oYu0Rm2foqmtwys/viewanalytics
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