Inferentialism and Science Education: Towards Meaningful Communication in Primary Science Classrooms

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Declaration

I, Shone Surendran confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Abstract

Classroom talk is a central aspect of teaching and learning science. A significant challenge for primary teachers is to think and talk about science with pupils in ways that support meaning-making in science classrooms that develops meaningful understanding. An influential response to this challenge is Mortimer and Scott's research framework. They analyse social interactions in science classrooms, identifying patterns that represent communicative and pedagogic practices that make classroom talk visible. Their representational approach is inspired by Anglo-American Vygotsky scholar James Wertsch and his sociocultural theory. However, the present thesis challenges sociocultural approaches, drawing on alternative but emerging Vygotsky scholarship. Of significant interest is Jan Derry's philosophical perspective, which attends to Vygotsky's Hegelian heritage, long-neglected by Anglo-American interpretations and (post-) Vygotskian research. Furthermore, her interpretation acknowledges developments in contemporary philosophy, namely 'Inferentialism' – a neo-Hegelian perspective on language, mind and epistemology. Inferentialism offers a more fine-grained analysis of thought and talk than representational approaches by privileging the role we humans, as rational, knowing agents, play in making judgments and being responsible for those judgments in discursive practices. Inferentialism offers rich theoretical resources in explaining meaningful communication that make these neglected human dimensions explicit. Adopting an inferentialist-Vygotskian lens to challenge Mortimer and Scott's meaning-making research framework, the present study illustrates how an inferentialist epistemology critically informs theory and analysis and illuminates practical challenges in science classroom research. This first involves re-theorising

concept-meaning and communication. Secondly, it involves a critical revision of analysing classroom discourse and, thirdly, a re-interpretation of meaning-making in classroom practice and pedagogic research. These critical insights systematically reorient our understanding of meaning-making, which remains under-theorised by sociocultural perspectives. This thesis aims to demonstrate how these inferentialist insights have implications for teachers in planning, teaching, and talking science in supporting children's meaningful understanding of science concepts in primary classrooms.

Impact Statement

This research study is the first to apply inferentialist theory in research on primary science and to the analysis of science classroom discourse. It is also the first to employ an inferentialist perspective in a doctoral study in science education research. This study, informed by the contemporary philosophy of language – *inferentialism*, aimed at developing practical and analytic insights on how primary teachers could better support their pupils in developing meaningful understandings of science concepts. The key outcomes of this philosophical study were theoretical principles and analytic insights that inform classroom research and practices. This study primarily constitutes a conceptual impact on research in science education at the primary school level. It nevertheless identifies a practical need to develop teaching resources to better support teachers in becoming critical authors in their lesson planning and classroom teaching. The inferentialist approach adopted in this study proposes the development of potential pedagogic resources and teacher education. These insights may extend to inform the development of the design of digital resources for teachers in collaborative and training contexts. Although the focus was on classroom discourse and science teaching, the research implications extend beyond classrooms to address analytic approaches, teaching resources and science communication more broadly.

These inferentialist insights have already had an impact on clinical communication research in healthcare. In offering alternative avenues in research on language, learning and communication, the present study has influenced several conferences with forthcoming publications in healthcare. While Vygotskian theory and inferentialism have informed research in healthcare separately, the present study integrates these areas through an inferentialist interpretation of Vygotsky. The present study contributes to emerging issues in the philosophy of medicine and related theoretical and analytical discussions. Consequently, it has applications for research undertaken in clinical communication, health literacy and patient education. Furthermore, the recent developments of inferentialism within design-based research methodology allow me to draw on my experience and expertise in Learning Sciences and technology-enhanced learning applications for the proposed future research in the design of digital communication interventions in healthcare settings. This research work is expected to offer fruitful opportunities to develop my research that applies to both classrooms and broader educational contexts.

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Table of Contents

Abstract 3

Impact Statement 5

Acknowledgements 7

Table of Contents 9

1 Introduction...11

PART I: Theoretical Orientations 31

2 The Challenge of Meaning-Making in Primary Science Classrooms 31

3 Investigating Meaning-Making: A Sociocultural Approach 61

4 Vygotsky Mind and Meaning: A Philosophical (Re-)Orientation 96

PART II: Analytic Considerations 139

5 Classification of Materials: Towards an Inferentialist Approach 139

6 Deontic Scorekeeping: Towards an Inferentialist Analysis of Discourse..............185

7 Normative Pragmatics of Discourse: A Critical Discussion 228

8 An Inferentialist Re-conceptualisation of Science Learning and Teaching 262

Part III: Practical Implications 281

9 Inferentialism and Primary Science: The Case of Planet Earth 281

10 Inferentialism and Primary Science Resources: Understanding Materials.........307

11 Conclusion and Implications...339

Epilogue 364

References 365

Appendices...380

In one substance there are many,
and in many things there is one meaning; reasoning thus,
everything becomes inseparably inclusive in knowledge;
not all know this great secret.

Narayana Guru- Philosopher of Advaita Vedanta[1]
Ātmōpadeśa Śatakam – Verse 73
(Hundred Verses on Self Instruction)

[1] Advaita Vedanta is a non-dualist school of Indian philosophy, committed to Absolute idealism. Narayana Guru is a prominent contemporary philosopher from South India. This is the school of Indian philosophy in which I trained. The translation has been taken from Nitya Chaitanya Yati, who, as my teacher, first introduced me to Western philosophy before my formal academic training (see Appendix 1 for details related to my researcher identity).

1 Introduction

We, humans, are inquisitive creatures. From ancient philosophies to modern sciences, humankind has been engaged in asking endless questions; thinking, talking, and trying to make sense of the phenomenal world around us. The discussions that manifest in primary science classrooms are no exception. They are places brimming with children’s claims and beliefs about the world. While science may offer exciting opportunities to explore and discuss our fascinating world with children, primary teachers are continually faced with the challenge of communicating the adult world of science in ways their pupils can understand. In this thesis, I am centrally concerned with the nature of meaning and communication and the role they play in science classrooms. My research focuses on primary science concepts, investigating classroom talk between teachers and pupils. I examine and explore the distinctive nature of these discursive practices that aim to develop meaningful learning and children’s understanding of science and scientific concepts.

Classroom talk research, as a field, has been evolving over the last four decades (Mercer and Hodgkinson, 2008; Mercer and Dawes, 2014). In science education, this field has led to various theoretical and methodological developments. For example, post-Vygotskian research has enjoyed developments in sociocultural discourse analysis and classroom research frameworks, such as the meaning-making framework (Mortimer and Scott, 2003). More recently, some researchers have signalled a need to recognise a certain level of stagnation within the field (Howe and Abedin, 2013; Mercer and Dawes, 2014). Howe and Abedin in reviewing over 225 papers across four decades suggested that ‘given an essentially static situation over 40 years ... arguably the characterization of dialogic patterns should not be accorded high priority when it comes to future research.’ (Howe and Abedin, 2013, p. 345 cited in Mercer and Dawes, 2014). Whereas other researchers have raised challenges within classroom talk research and subsequent teacher development programmes (Biesta 2010; Lehesvouri, Viiri and Rasku-Puttonen, 2011; Mercer and Daws, 2014). My approach to developing the present thesis sits in contrast to that of classroom talk research or sociocultural approaches. The present study draws inspiration from contemporary developments in the philosophy of language, mind and epistemology, namely 'inferentialism' (Brandom, 2001, 1994). This philosophical line of inquiry has parallels with emerging cultural and philosophical developments in Vygotsky scholarship (Bakhurst, 2011; Derry 2011; Dafermos 2018; Yasnitsky and Van der Veer, 2015). This emerging Vygotsky scholarship takes issue with Anglo-American interpretations and subsequent (post-) Vygotskian research. In this thesis, I illustrate how inferentialism offers an alternative philosophical and theoretical lens for investigating classroom talk. Inferentialism reveals innovative new dimensions in linguistic meaning and communication, by attending to certain distinctive human features in thought and talk. These new dimensions, I will argue, illuminate certain challenges facing classroom talk research. Furthermore, I contend that inferentialism, in providing a finer grain of analysis of concepts, meaning and communication than sociocultural analysis, and offers rich theoretical resources in characterising classroom talk, meaningful communication, and learning. The inferentialist insights gained, I argue, serve to illuminate the nature and role science concepts play in classroom discourse and in developing an understanding of science concepts. This thesis demonstrates how such inferentialist insights have implications of significance for teaching and learning science in the primary classroom.

1.1 The Status of Primary Science and Why it Matters

Primary teachers in schools across the United Kingdom are confronted with the challenge of teaching a wide range of subjects. Inducting children into any one of these subjects is no easy task. Institutional pressures of schooling and delivering the national curriculum weigh heavily on the teacher, especially concerning science, with constraints on quality and affordable CPD (Continued Professional Development) and resources (CBI, 2015; Score, 2013; Wellcome Trust, 2014). One may wonder whether we should really be concerned about teaching and learning science at such an early stage of formal learning, especially when numeracy and literacy are the key priorities (Wellcome Trust, 2014). Recent government reports and educational campaigns have reported on the role of science in the primary curriculum and primary classroom, raising concern and awareness about why primary science should matter (CaSE, 2016; Wellcome Trust, 2016; 2014; CBI, 2015).

The National Primary Curriculum for England and Wales recognises Science as a core subject (DfE, 2014). Over the last five years, several studies and news media reports have exposed mounting evidence that suggests, that while science remains a core subject on paper, the reality is a 'general decline' in primary science teaching (Wellcome Trust 2013; CBI, 2015; Richardson, 2015). Until 2009, pupils were required to sit statutory science exams in their final year of primary education. Exams led primary schools to focus on revision, raising concerns that the 'breadth and richness in the teaching of science' was subsequently being compromised (Wellcome Trust, 2014). Recognition of the time and investment required to plan and prepare quality science lessons and in 2009, testing by a formal examination in primary science was removed all together (CBI, 2015; Lievesley, 2014). The move, unfortunately, resulted in science being perceived as less important than English and

Maths and a decline in its status ensued (Wellcome Trust, 2011). Now, compared to other core subjects English and Mathematics, primary teachers typically spend a mere two hours a week seeking to engage, explore and discuss science with their class (McCrory and Worthington, 2018; CaSE 2017). In 2014, the revised primary curriculum was implemented in England and Wales (DfE, 2014). Reports have continued to show a steady deterioration of primary science from a 'general decline' (Wellcome Trust, 2014) to clearly being 'downgraded' (Ofsted, 2019). In 2018, the Chief Inspector of the Office for Standards in Education (Ofsted), Amanda Spielman, spoke of the 'undue focus on examinations and schools' league table performances' as leading to incentivising the de-prioritisation of science (Driver, 2018). Inspectors found schools that focussed on English and Maths, which led to pupils in higher year groups being given 'low-level worksheets' and 'little consideration' given to understanding scientific concepts and skills (Schoolsweek, 2019). In light of their curriculum research, in 2019, the watchdog Ofsted warned that science 'has clearly been downgraded in some primary schools' since the key stage 2 science test was scrapped in 2009 (Ofsted, 2019). Ofsted has warned of the 'serious impact' on understanding and knowledge of science caused by a limited curriculum, 'which may in turn stifle pupils' later curiosity and interest in the sciences.' (Ofsted, 2019).

Growing awareness of this continuing degradation has also garnered attention at the level of the national government, which views primary teachers as carrying the burden of inspiring and energising future generations of scientists and engineers (CBI, 2015). The BBC reported on how John Cridland, as the director of the Confederation of Business Industry (CBI) had identified a growing need and demand for primary teachers to provide high-quality and inspiring science lessons, in the absence of which, we risk children losing interest in science 'before they hit their teens’ (Richardson, 2015). The role and significance science play in primary education is being recognised as an issue of growing concern within primary schools and classroom teaching and at the level of the national government. The above research studies and reports in reviewing the state and status of primary science also highlight the plight of primary teachers on the ground. Identifying the need to address the level of support primary teachers and subject leaders require as the pressures and constraints in teaching science mount has been an animating factor in my research study. As someone who became disenchanted with science at secondary school and dropped out of engineering at higher education, the need for inspiring interest and maintaining curiosity resonates deeply with my own experience of science education. It is against the backdrop of my personal experience with science education and transition to philosophy and the history of science that I turn to present my research rationale.

1.2 Research Aim and Rationale

Science classrooms are sites of teaching and learning, where the meaning of scientific terms and concepts are discussed and developed. The classroom talk during science lessons provides ideal scenarios in which to explore and examine Vygotskian theories of learning and development (Mortimer and Scott, 2003; Scott, 1998). My research study focuses on primary science; however, the main thrust of the thesis lies in a philosophical reassessment of Vygotskian theory and subsequent reorientation of how key terms such as ‘concepts’, ‘meaning’ and ‘development’ and learning are interpreted. Primary science lessons and dialogues offer a practical context for examining and understanding meaning-making. Drawing on the emerging philosophical scholarship of Vygotsky's work (Derry, 2013a; 2017; 2020), I aim to re-examine the nature of classroom talk and its implications for teachers and their classroom practices. It was a certain set of circumstances that led to primary science becoming the central focus of my research study. As I narrate my research rationale, I offer a brief account of those circumstances and the central problem that sits at the heart of my thesis, namely ‘meaning-making’.

1.2.1 Meaning-Making Research and Why Philosophy Matters

My research was initially concerned with the design of technology-enhanced learning environments. My focus was on the ‘transfer of learning’ theory situated in human-computer interaction (HCI) and sustainability education. A desire to foster a deeper awareness of human communication within educational environments first-hand led me to approach a sustainable school and primary classrooms. As I observed classroom science discussions, I saw how easily primary teachers became entangled in a web of ideas in thinking and talking about science with children. The situation they faced was difficult to navigate yet inescapable. For example, in teaching about Earth and Space, the teacher is faced with reconciling the shape of the Earth with our everyday experience of it being flat. In teaching materials, the teacher needs to help children understand how even soft things, such as clothes and sponges, are considered ‘solids’ in science. Observing these classroom scenarios made me appreciate how seemingly simple concepts become increasingly complicated when discussed and thought through. It sparked my curiosity in thinking about science concepts, their meaning, and the challenge of engaging and supporting children in developing an understanding of scientific ways of thinking and talking in the primary classroom. This challenge of communicating and understanding science concepts in classrooms and attempting to comprehend how meaning is established through our thought and talk began to dominate my thinking and ultimately altered my research focus and trajectory. It was only much later I came to realise that this communicative challenge, within the science education literature, was referred to as ‘meaning-making’. The main aim of my thesis lies in grappling with this central idea of ‘meaning-making’ and how teachers approach classroom talk with their pupils. In science classrooms, teaching science entails communicating science concepts in a manner that helps children develop meaningful understandings of what the teacher says, does, and intends to convey, that is, to initiate them into the uses of science concepts and participating in classroom science talk. My main concern in reflecting on these issues was how classroom talk research addresses teachers’ thinking and intentions in talking with her pupils. In practical terms, the issue concerns how classroom talk research informs teachers who are constantly faced with responding to the changing and dynamic nature of classroom talk. Teachers not only need to respond to what pupils say but what pupils mean in the course of classroom talk. For example, a child may say that ‘sand is a solid’, by which they also mean ‘therefore it cannot be a liquid’. It is through classroom talk that the child's presuppositions can be addressed.

As my research trajectory shifted, I turned my attention to science education literature, where I encountered a well-established research framework developed by Mortimer and Scott (2003). They had developed an approach to investigating meaning-making informed by post-Vygotskian theory. Their approach brought together the two aspects of conceptual content and communicative approach together in investigating and understanding the issues of meaning-making. Their framework has been referred to as the meaning-making framework (MMF). It has contributed significantly to the development of classroom talk research on the one hand while informing the nature of conceptual development on the other. Inspired by post-Vygotskian sociocultural theory, the framework was developed within the context of secondary school science classrooms. Nevertheless, it has been widely adopted across both primary and secondary science, informing both classroom research and teacher resources (McMahon, 2012; Mercer and Littleton, 2007; Mortimer and Scott, 2003; Scott and Ametller, 2007; Tytler and Aranda, 2015). Furthermore, it has been employed in teacher education and continuing professional development (CPD) programmes in the UK and abroad (Mortimer and Scott, 2003; Lehesvouri et al., 2011; Lehesvuori, Viiri, Scott, 2009; Mercer and Dawes, 2009; Sedova, Sedlacek and Svaricek, 2016).

My route into the field of science education research is non-traditional. It sits in contrast to an empirical study motivated by professional insight or a 'gap-finding' approach (Alvensson and Sandberg, 2013). My study has been inspired by philosophical concerns related to sociocultural theory and the conceptualisation of meaning, communication and concept development. It may be prudent at this juncture to provide some personal background and an academic context to this non-traditional route. This involves my interest in Learning Sciences as a pathway to educational research more broadly. Academically, my studies followed a scientific path involving a short-lived career as an undergraduate in Aerospace Engineering. However, that ended with an unorthodox move to pursue Philosophy and Philosophy and History of Science as a postgraduate. It was my overseas work on an educational project involving the Learning Sciences that led me to pursue an MRes in Social and Educational Research. I considered my academic background as offering a rather exotic standing in the field of Learning Sciences, viewed as a benefit rather than a liability. Consequently, my approach to educational research tends to be philosophically oriented toward problematising conceptual issues. I specifically have in mind here the concept of 'meaning-making' and the discourse analytic approach adopted by the meaning-making framework. Initially, I had trouble understanding how an analysis of classroom discourse that represents patterns in our talk and social interactions served to explain the nature and complexity of the dynamic nature of classroom thought and talk. I also grappled with understanding concepts and their meaning that seemed, on the one hand, to locate it in language and yet remained in the mind of the learner[2]. However, I was quick to assign any reservations I had with a well-established framework to my ignorance as a novice rather than having any valid basis. That was until I encountered the Vygotsky scholarship of Jan Derry and other related scholars. Being of a philosophical stripe, Derry's scholarship lent legitimacy to some of my own concerns and intuitions. Drawing on a Hegelian perspective, her re-assessment of Vygotsky's corpus not only served to illuminate the problem of meaning-making but instigated a further twist to my already altered research trajectory. Subsequently, my research would seek to redress certain epistemological and methodological issues prior to any empirical considerations. Much of the research in classroom talk in science classrooms has been informed by linguistics, psychology and more recently post-Vygotskian theories or more specifically sociocultural methodology. In refocusing my research study, inspired by Derry's philosophical scholarship, I undertake a critical review of research frameworks founded on sociocultural theory, which underwrites my central thesis. This study aims to reorientate an understanding of 'meaning-making', inspired by a philosophical reading of Vygotsky attending to his Hegelian heritage, which subsequently aims to respond to the challenge teachers face in teaching and learning science concepts in the classroom.

[2] This was a personal reservation I had derived from a Eastern non-dualist background but something I have learned to dismiss in my academic studies. For more details related to my personal and researcher identity please see appendix 1.

1.2.2 Vygotsky, Brandom and Classroom Research

The emerging field of Vygotsky studies (Yasnitsky and van der Veer, 2015; Yasnitsky, 2019) together with alternative Vygotsky scholarship (Bakhurst, 2011; Derry 2013; Dafermos, 2018; Roth and Jornet, 2017), spotlight inherent limitations within mainstream Anglo-American scholarship. A prime example is the post-Vygotskian sociocultural theory, which inspired Mortimer and Scott's meaning-making framework. Anglo-American scholars considered Vygotsky a psychologist. In contrast, Derry's scholarship reads Vygotsky as an epistemologist and a philosophical thinker in his own right. Consequently, she argues, Western scholars have tended to neglect the significance of the Hegelian tradition in which Vygotsky generated his work. This philosophical restorative account of Vygotsky is not simply a historical correction. Derry relates her re-examination of Vygotsky's works to contemporary developments current in analytic philosophy. She alerts us to the significance of contemporary Hegelian (neo-Hegelian) philosophers and, in particular, Robert Brandom and his philosophy of language, epistemology and semantic theory termed *inferentialism*. Brandom shares with Vygotsky a specific concern in attending to the distinctive human dimensions in our discursive practices. For Brandom, what makes human knowing and our discursive practices distinctive, is our *sapience*, that is our rational awareness and autonomy. This is our capacity to freely make rational judgments and to be responsible for them and held accountable by other language-using creatures. His philosophy of language, *inferentialism*, takes our distinctive capacities as language-using, discursive creatures as his point of departure. He views our discursive practices as social practices in articulating our judgments as reasons. Human communication is viewed metaphorically in terms of a distinctive sort of game that we, rational, language-using creatures, participate in as players. Brandom refers to our discursive practices as the *game of giving and asking for reasons,* and in playing this game come rules. Just as rules determine permissible and impermissible moves in playing chess, these rules govern what ought or ought not to be said or done in discursive practices. These rules or norms of rational discourse govern the structure, dynamics and freedom in the games we play. These rules govern the appropriateness of judgments we make in applying concepts, using words or making claims in dialogue. Brandom utilises his metaphor in leveraging a sophisticated account of what is involved in our believings, sayings and doings in communicating with each other, not only in ways that make them successful but also meaningful within a given discourse. The present thesis argues that Derry's inferentialist reorientation of Vygotskian theory (2013) offers a unique and innovative critique of the meaning-making framework. The main thrust of this thesis lies in highlighting just how inferentialism, in privileging the role of our reasoning and autonomy in an explanatory account of meaning and communication, provides a finer grain of analysis of meaning and dialogue than the meaning-making framework. I aim to demonstrate how this inferentialist description of classroom talk makes explicit certain distinctive dimensions in our thought and talk that remained neglected and out of view of post-Vygotskian theories. This thesis illustrates and exemplifies how inferentialism offers critical resources in a re-assessment of pedagogic issues related to concept formation, classroom talk and teaching practices that aim for meaningful conceptual understanding in the primary science classroom. A key feature of inferentialism, presented in this thesis, lies in acknowledging the central role our judgments and rational autonomy play in thinking and talking in social and discursive practices of primary classrooms.

Although inferentialism is an emerging theory in educational research, it remains very much in its infancy. Investigation of the pedagogic implications of this alternative Vygotsky scholarship has been largely developed in mathematics education (Derry, 2017; Bakker and Derry, 2011), with studies in other domains manifesting gradually (Causton, 2019; Derry, 2020; Firth, 2017; McCrory, 2015). My research focuses on exploring and examining various ways to describe and conceptualise classroom practices and paradigmatically classroom talk. However, to avoid a purely theoretical treatment, in developing a critique of the post-Vygotskian meaning-making framework informed by an inferentialist perspective, I provide illustrative examples drawing inspiration from my own fieldwork conducted in primary classrooms. My purpose was not to directly analyse data from this fieldwork, rather I used this fieldwork, working collaboratively with a Year 5 primary teacher and the school science lead in planning and teaching science lessons to inform my conceptualisations and arguments. I draw on episodes and insights using them illustratively to support my theoretical analysis of classroom interactions that seek to develop conceptual understanding through meaningful dialogue, encapsulated in the term ‘meaning making’ (Mortimer and Scott, 2003). Working through theoretical issues situated in practical classroom challenges serves to spotlight critical challenges facing post-Vygotskian theories but also considers practical implications for science education in teaching and learning science in primary classrooms. The aim of my thesis is thus two-fold: first, to illustrate how an inferentialist interpretation of Vygotsky, as an alternative theoretical framework, illuminates and makes explicit the nature of meaning and communication, neglected by Mortimer and Scott’s analytic framework and post-Vygotskian theories more broadly. The second is to discuss in more practical terms, how this theoretical re-orientation serves to redress challenges of science teaching practice in the primary classroom and the thought and talk for meaningful understanding of scientific concepts.

1.2.3 A Turn of the Kaleidoscope

My research inquiry follows a systematic and critical review of key concepts informed by post-Vygotskian theory, such as *concept formation, classroom discourse and meaning-making*. As I systematically set them in contrast with Derry's inferentialist reading of Vygotsky, this thesis aims to illustrate how a reorientation of key terms exposes certain blind spots and subsequently reveals neglected features of language and human discursive practices. Brandom considers his approach to explaining meaning and communication as a paradigmatic alternative to traditional strategies in the philosophy of language, mind and epistemology. Traditional explanations of meaning and communication appeal to some referent-reference relation or sign that stand for something, in short, some form of representation. Brandom inverts the traditional representational explanation by giving pride of place to the role of judgments and our reasoning, that is our inferences in an account of understanding meaning as a distinctly human affair. Thus, on Brandom's analysis of language, meaning and communication, the linguistic and pragmatic features of discourse are surface-level features or 'representational', that remain subordinate to inferential ones, central to explaining what we humans *do* when *we* engage in meaningful thought and talk with each other.

An inferentialist re-interpretation of Vygotskian theory and subsequent implications for understanding and describing discursive practices are captured by Derry's fitting analogy of a kaleidoscope, which she expresses as follows:

> For what we have with Brandom is a 'turn of the kaleidoscope' where familiar elements in an epistemological account are reconfigured and assume a new shape. ...this reconfiguration can play a positive part in thinking about educational issues, such as the structure of knowledge. (Derry, 2013b, p. 231).

To grasp what this 'turn of the kaleidoscope' entails, at least in relation to the meaning-making framework (MMF), requires identifying key representationalist assumptions that underpin the sociocultural theory and, by implication, MMF. It also involves coming to understand how an inferentialist orientation reconfigures and reinterprets practical situations and discursive practices as a whole. Inferentialism alerts us to a whole other dimension in what humans do when we participate in thinking and talking with others, in using language and concepts in discursive practices or classroom talk. Brandom's inferentialism foregrounds and makes explicit the rational, expressive, normative and inferential dimensions of language, or more specifically, the distinctively *human* use of language, which involves not only awareness of what is said but responsiveness to what is *meant*, that is our reasons articulated by our claims expressing our thoughts and beliefs. For example, a child may refer to a spider as an insect, which may not be problematic in everyday situations. However, in the science classroom, what is meant by 'insect' and its use in relation to the spider, understood in scientific terms, relates more specific ways to the idea of an arachnid as opposed to an insect, which subsequently relates to various other ideas, such as, 'having eight legs' as opposed to six, which begins to problematise more everyday ways of thinking and talking about spiders. Viewed from within an inferentialist paradigm, my research aims to offer an alternative to the representationalist approach of post-Vygotskian theory in investigating and understanding meaning-making and conceptualising the nature of thought and talk in classrooms. This thesis aims to show how new dimensions revealed by an inferentialist perspective offer an approach to researching and interpreting classroom talk and meaning-making that attend to features that lay beneath surface-level descriptions of classroom thought and talk. This study aims to exemplify, in theoretical, methodological and practical terms, the implications of this epistemological reorientation and paradigmatic reconfiguration that Derry's scholarship has initiated by applying inferentialism to education. In the chapters that follow, I systematically reconfigure and discuss issues concerning concept-meaning and their development, methodological issues related to classroom discourse and its analysis, and finally, relating these back to issues of classroom interactions, talk or meaning-making. With my research aim and rationale in view, I conclude this introduction by providing the structure of my thesis.

1.3 Structure of the Thesis

In this introduction, I set out my research aim, orientation and approach to the problem of meaning-making in primary classrooms, focusing on the nature of classroom talk in supporting pupils to develop an understanding of science concepts. I begin my next chapter (Chapter Two) with a classroom scenario. I illustrate the challenges that teachers face in teaching, talking, and doing science with children. The scenario serves to situate the problem of meaning-making within a primary classroom context. I also introduce Mortimer and Scott's analytic research framework as an established sociocultural response and proposed resolution to the problem of meaning-making. I review the structural features of this analytic framework and its implications for science teaching. This initial review provides a strategic orientation for developing the discussion of science teaching and learning across remaining chapters.

Chapter Three explores the meaning-making framework's theoretical orientation, reviewing its historical development rooted in sociocultural theory and research methodology. I discuss the role of MMF in teacher professional development as a form of *dialogic pedagogy*. I conclude by reviewing emerging research in dialogic classrooms and teacher development and how emerging Vygotsky scholarship offers insight into current and critical challenges on three levels: theoretical, methodological and pedagogical.

The fourth chapter begins to deconstruct the meaning-making framework, starting with its theoretical roots and working towards practical implications in subsequent chapters. I take my lead from Derry's scholarship that problematises Anglo-American (post-) Vygotskian scholarship and sociocultural theory that emerges as a result. Derry's reassessment of Vygotsky by addressing his neglected Hegelian heritage involves getting to grips with contemporary developments within analytic philosophy, in particular the philosophy of neo-Hegelian Robert Brandom. As an emerging theory of both semantics (concept meaning) and pragmatics (language use), Brandom's philosophy of inferentialism holds significance for issues related to theorising meaning-making in classrooms, which has direct implications central to my thesis. As I introduce inferentialism, tracing it back to Vygotsky and running it forward to the challenges of the classroom, I systematically work out the inferential turn of the kaleidoscope developed across several chapters.

The remaining chapters, discuss, analyse and illustrate the implications of inferentialism for: a) the theorisation of concepts and meaning, b) the theorisation of communication and analysis of classroom discourse and c) the implications for understanding meaning-making in classroom practice, teacher development and pedagogic research. Understanding inferentialism involves grappling with some of Brandom's technical vocabulary. So, Chapter Five renders his philosophy of inferentialism in more accessible terms by grounding it in practical issues of classroom teaching and learning of science. I focus on the primary science topic of Materials and take as my initial entry point a classroom discussion on whether sand is a solid or liquid. I explain Brandom's inferentialist theory of concepts (inferential semantics) using the practical activity of classifying materials into solids, liquids or gases. I discuss the implications of this inferential view of concepts for how the common approach to science teaching employing the classification of materials may be inferentially re-oriented. With an inferentialist interpretation of concept meaning in view, the remaining chapters build on this semantic account in addressing classroom talk and pedagogic practice.

Chapters Six and Seven discuss Brandom's theory of communication and his normative pragmatic view of discourse. Chapter Six extends his metaphor of language as a game and concepts as rules. Our discursive practices are explained in terms of players as involved in a kind of *scorekeeping* in playing the game i.e., dialogue. His scorekeeping account is intricate but illuminates certain new normative dimensions in our discursive practice, that is, by taking our autonomous rational judgments as central to his explanatory account. Inferentialism opens certain alternative interpretations in the analysis of classroom dialogue and scientific discourse, which I demonstrate using a classroom dialogue on forces. Chapter Seven is a critical discussion of sociocultural discourse analysis and its limitations. I discuss the implications of inferentialism in extending beyond discourse analysis and dialogic pedagogic insights. Chapter Eight brings the discussion to a close by taking

Brandom's two-sided account of language in view, his *inferential semantics* and *normative pragmatics* and offers an inferentialist metaphor of teaching and learning that sits in contrast with sociocultural (participation) and socio-constructivist (acquisition) metaphors, namely: mastering.

Chapters Nine and Ten provide an inferentialist commentary of two illustrative examples from primary science. I draw inspiration from my fieldwork in planning and reviewing lessons with a Year 5 primary teacher and school science lead. I selected two different primary science topics; the first is 'Earth and Space' and the second discusses 'Materials'. In discussing 'Earth and Space', I focus on the implications of inferentialism for teachers in planning and talking about science. From an inferential perspective, scientific concepts are not isolated atomic entities, nor are they scientific vocabulary explained by the context of their use. The illustration spotlights the *inferential role* concepts play in our thought and talk as part of a web of reasons, a holistic relational network of claims (inferential semantics), which underwrites the correct application of concepts in scientific discourse. I illustrate how this holistic network serves as a conceptual system that provides teacher access to a coherent, logical space: having an orientation to this *space of reasons*, allows her to not only plan but navigate her teaching sequence with a greater level of freedom. Having an (inferential) orientation to this space allows her to be responsive to a range of possible consequences (normative pragmatics) in teaching and talking with her pupils.

In the final topic of 'Materials and their properties', I return to discuss the classroom classification activity initiated in Chapter Five, albeit with a view to teacher resources related to the science topic. I illustrate how the representationalist paradigm remains present and continues to constrain the role of teacher resources. I present a counterpart to the classroom resource presented in Chapter Five, offering practical inferentially-orientated teacher resources. The resources and examples serve to illustrate how teachers need a first-person perspective in using concepts in thinking and talking to develop an awareness and receptivity to the use of concepts as part of a norm-governed practice. Scientific discourse constitutes norms governing the correctnesses of discursive practice that serve as rules of the game. These norms of scientific discourse, rules of the game, so to speak, not only govern the correctness of classroom science talk but underwrite the teacher's responsiveness to reasons articulated by her own pupils in their thought and talk. In assessing their talk as articulating their inferential reasoning, in playing a *game of giving and asking for reasons*, the teacher not only evaluates their claims but is engaged in calibrating their use of scientific concepts and their reasoning according to the norms or rules.

In concluding my thesis, I summarise the systematic reorientation of meaning-making from a representationalist to an inferentialist interpretation, referred to earlier as the ‘turn of the kaleidoscope’ (Derry, 2013b). It summarises a holistic twist on a distinctly neo-Hegelian turn on issues of thought, talk and human understanding, which sees my thesis run from philosophy to pedagogy. Inferentialism offers rich theoretical resources in making explicit the nature and *inferential role* of concepts and the *normative character* in their use in thought and talk. This thesis argues that these critical insights not only illuminate emerging challenges within research on dialogic teaching and teacher development programmes but open new possibilities and avenues for future classroom research. An inferential reorientation on the issue of meaning-making in classrooms has implications for planning, teaching and talking to children in developing a meaningful understanding of science concepts in thinking and talking primary science. With the structure of my thesis in view, in the next chapter, I turn to discuss a practical scenario of meaning-making from the primary classroom.

PART I: Theoretical Orientations

2 The Challenge of Meaning-Making in Primary Science Classrooms

Teaching science at the primary level involves engaging children in talking and making sense of the world around them. Talking about the world in everyday language familiar to children sits in stark contrast to the technical scientific language and ways of thinking and talking about the world introduced in science lessons. Such differences are further compounded when familiar everyday words such as ‘materials’, ‘hard’, ‘force’ or ‘weight’ are used in different ways and interpreted with very different meanings within science classrooms. In this chapter, I introduce a long-standing problem in teaching and learning science: the challenge of communicating science concepts in talking to children in ways that support meaningful conceptual understanding. I provide an illustrative scenario to situate this problem and spotlight the challenges teachers face in thinking and talking about science concepts in primary classrooms. I then discuss a response to this pedagogic challenge, which is well-established in the science education literature. I refer here to a specific research framework developed by Eduardo F. Mortimer and Phil H. Scott, which responds to this challenge by offering an analysis of classroom science talk and interactions in teaching and learning science (Mortimer and Scott, 2003).

2.1 Introducing the Problem of Meaning-Making

When teaching science, the primary teacher often finds herself faced with the challenge of introducing scientific words and supporting her pupils in developing meaningful understandings of these scientific concepts. Let us take a simple example, such as the concept of ‘solid’. In considering what a ‘solid’ is, one may think of some typical objects like walls, doors, tables or a rock. They display certain properties such as: being hard, being able to hit it, physically handling it, breaking it or not being able to put your hand through it and so on, the kinds of properties associated with 'solidity'. However, the scientific concept of 'solid' is understood somewhat differently. An object is 'solid' not simply because it is hard, has a shape, and is not hollow. For example, take a sheet of paper. You cannot knock on a piece of paper as you can on a table or wall, while unlike the table or wall, you can easily poke your hand through it. Scientifically speaking, paper is considered a 'solid'.

Let us consider a scenario in the primary classroom. I draw on a common approach to teaching about materials and their properties: the classification of materials into solids, liquids and gases. Take classifying sand, for example. Like most liquids, you can put your hand through it; it takes the shape of the container it is put into and can be poured. Yet, it is solid because you can hit it and physically handle it and has hard grainy bits. Introducing sand immediately presents a problem as it does not easily classify into the clear-cut distinction between solid, liquid and gas. The example of sand illustrates how the seemingly simple and benign question, such as 'what is a solid?', on closer reflection, quickly unravels to become a rather messy and complex problem, which the primary teacher has to grapple with in developing the lessons and discussing it with her class in developing pupils' understandings.

In classifying sand, a child may consider it a solid as it is hard. Sand has hard grainy bits. However, the term 'hard' can be used in different ways to mean different things. In everyday ways of thinking and talking about 'hard', it may be thought of as something you can hit or that you cannot put your hand through. This, of course, relates to the everyday concept of 'solid' as defined by the Oxford dictionary as something that is ‘not hollow or containing spaces or gaps:…’ (Stevenson, 2010a). A scientific understanding and use of the term ‘hard’ expresses a different meaning. The concept of ‘hard’ is an empirical measure of material property, namely *hardness*. Wenham (2005) provides a definition for primary science, stating that ‘Hardness is a measure of how easy/difficult it is to dent or scratch the surface of a material’ (p. 106). To scratch or dent a material, its surface has to be penetrated and this requires force. The response of materials and objects to the application of forces is known as mechanical properties (ibid.). On this scientific understanding of ‘hardness’ as a measure of a mechanical property, solid materials are not only ‘hard’ but can also be ‘soft’. This scientific conception of hard can be quite counter-intuitive to our everyday conceptions and language. As Wenham claims, ‘[i]nvestigating and understanding mechanical properties has a reputation for being complex and difficult, but much of the difficulty comes from a confused use of language...’ (Wenham, 2005, p. 104, *italics added*).

Sand, as a solid material, displays mechanical properties, which liquids lack. Nevertheless, it displays liquid-like properties; it takes the shape of a container and if tilted, can be poured out and appears to flow as liquids do. Just as mechanical properties are a key feature of solid materials, a key property of liquids is viscosity or, in everyday parlance, runniness. The ease of flow is a property that may be shared with liquids and granular materials such as sand, sugar or salt, as they can also be poured. However, liquids do not form a heap when poured onto a table. Liquids have no shape of their own. This can be demonstrated in classrooms by focusing on individual grains or droplets under a magnifying glass. Each grain can be moved, pushed and squashed as it retains its shape, unlike a drop of liquid (Wenham, 2005). This is important in coming to understand the scientific conception and use of the term ‘flow’. Skamp defines the viscosity of a liquid as ‘a measure of its resistance to flowing’ (Australian Academy of Science, 2014c, p. 19). While this is a property internal to liquid substances, for example, water and vinegar flow quickly, while treacle and honey with high viscosity flow slowly. However, with granular materials, although they can be made to flow, it is a collective property of individual sand particles rather than the material substance itself. This granular flow is to be differentiated from the liquid property of viscosity.

Sand as a material illustrates how both solid and liquid properties can be displayed depending on whether it is viewed in terms of its particulate or bulk properties. During science lessons, many everyday ideas are challenged; conversely, many scientific ideas introduced may seem counterintuitive. For example, in our everyday language, ‘solid’ and ‘hard’ are used synonymously, as contrary to being soft. However, these concepts and meanings function in very different and counter-intuitive ways in the context of classroom science thought and talk. Science classrooms are spaces where the opportunity and the need arise to make specific distinctions in using and understanding terms such as ‘solid’, ‘hard’ and ‘soft’, ‘liquid’, ‘flow’. The seemingly simple activity of classifying sand reveals how limited our everyday vocabulary is in thinking and talking about materials (Hall, 2014). The primary science of materials introduces a very different set of meanings to very familiar words and in thinking through science reveals the complexity of the world we live in.

Although teachers may initially assume thinking and talking about materials and their classification to be simple and straightforward, it is important for them to recognise associated difficulties. Appreciating the complexity of scientific thinking and talk, that is, the concepts and the language of science, it is understandable why ‘[s]cience can be a challenging subject both to learn and, of course, to teach!’ (Scott, 2008, p. 18). In classroom discussions of materials and their classification, the terms ‘solid’, ‘liquid’, ‘gas’, ‘hard’, ‘soft’, ‘flow’ and other related concepts all play a role in coming to think, talk and understand the scientific conception of materials and their properties. An appreciation of the precision and clarity that the scientific language offers is crucial for teachers in approaching teaching and learning science. These issues of language and meaning quickly confront primary teachers in discussing complex natural phenomena and the limitations of our everyday language in thinking and talking about them. This issue is even more pressing for teachers at the primary level because most are likely non-specialists in science. According to a study by the Royal Society, only 3% of UK primary teachers have a science degree (Royal Society, 2010). The illustration of classifying materials highlights the conceptual and pedagogic challenges involved in science talk in classrooms, in coming to use scientific terms and how seemingly simple tasks become quickly complex territories during classroom discussions. However, considerable contestation remains regarding pedagogic strategies and resources (Skamp and Preston, 2015). I address these issues in later chapters as I discuss concept-meaning, classroom talk and meaning-making (see Chapters Five, Seven, Ten, respectively).

2.1.1 Classroom Talk and Meaning-Making Research

Teachers at primary and secondary levels face significant challenges in teaching, talking and doing science. Central to their trade is planning and orchestrating meaningful *classroom talk* with pupils to develop their understanding of science concepts (Barnes, 1976; Mercer and Hodgkinson, 2008; Lemke, 1990; Mortimer and Scott, 2003, Ogborn, Kress and Martins and McGillicuddy, 1996). Subsequently, the challenge of classroom talk has become a significant focus in contemporary science education research (Driver, Squires, Rushworth and Wood-Robinson, 2015; Scott, 1998; Russell, Longden, McGuigan, 1998). Research on classroom talk has been an active field for over forty years (Mercer and Dawes, 2014). During this time, educational research has witnessed a sea change from approaches focusing on individual cognition to emphasising the social context of learning and development (Mercer and Dawes, 2014; Scott, 1998). In the wake of this growing trend, science education research saw a marked increase in investigations that focused on the role language and social interactions played in influencing learning (Scott and Ametller, 2007; Lemke, 1990; Mercer, Dawes and Staarman, 2009; Mortimer and Scott, 2003).

As educational research turned its attention towards examining and analysing classroom talk, Mortimer and Scott (2003) developed a framework based on empirical studies of science classrooms that integrated several developments within science education and classroom talk research, which contributed significantly to both fields. Douglas Barnes (1976), in his seminal book ‘From communication to curriculum’, drew attention to how classroom communication and talk is all too often ‘taken for granted’; a view echoed in the ‘ground-breaking’ work of Mortimer and Scott in observing and analysing science classroom talk (2003, p. ix). Their observations of classroom teaching sought to describe and illuminate the problem of meaningful communication between teachers and pupils in teaching and learning science. They focused on the communicative interactions between teacher and pupils in developing an understanding of science concepts, designating the problem of classroom talk and communication as ‘*meaning making*’, a term inspired by the work of Jerome Bruner and his characterisation of a ‘culturally-orientated psychology’ in education (ibid.; Scott, 1998). Mortimer and Scott developed a research framework for analysing classroom talk and meaning-making interactions in science classrooms (Mortimer and Scott, 2003; Scott and Mortimer, 2005) or a meaning-making framework (MMF). Within science education, their framework has become widely adopted in classroom research and has significantly impacted teacher training and pedagogic resources in secondary and primary science alike. Beyond science education, it contributed to advancing the field of classroom talk research more broadly (Mercer and Hodgkinson, 2008; Mercer and Dawes, 2014; Mercer et al., 2009).

By researching teaching practices and observing science classrooms, Mortimer and Scott recognise pedagogies emphasising student-centred approaches involving *active learning* (Mortimer and Scott, 2003). They acknowledge many benefits such pedagogic approaches offer, which sit in stark contrast to presentational or instructional models of teaching, where the teacher would be situated at the front of the class with students taking a more passive role. However, they argue that although classrooms today see children 'out of their seats' engaged in collaborative tasks and '*hands-on* practical activities' (Mortimer and Scott, 2003, p. 1), which may engage students, these activities 'cannot speak for themselves' (ibid.). In other words, doing or engaging in scientific activities does not necessarily develop an understanding of scientific knowledge.

Their primary concern with such 'active' approaches is the under-representation of the *scientific story* in a given teaching sequence and the subsequent under-utilisation of *classroom talk* in developing this story. Their studies build on classroom talk research in identifying the neglected role of 'talk' in the science classroom. Further, they argue, 'the ways teachers interact with their students in talking about the science subject matter at hand.' (Mortimer and Scott, 2003, p. 2), are crucial to analysing and understanding the *differences* in teaching approaches that aim for meaningful conceptual understanding (ibid.). The central focus of their research lies in identifying the challenges that teachers face in conventional everyday teaching practice as opposed to providing practical strategies or activities. They claim that in informing teaching practice, ‘the priority must be, first of all, to make these existing practices more “visible”, and then to point towards how they might be extended by employing the different kinds of interactions...’ (ibid., p. 5). As they attend to the neglected aspect of ‘talk’ in classroom research, Mortimer and Scott’s analytic framework not only differentiates between teaching approaches but in making the role classroom talk plays in teaching and learning science visible, they offer an approach to illuminate ways to promote meaningful science learning. Put differently, the framework contributes and holds the potential to resolve the problem of meaning-making in science classrooms.

2.2 Researching Meaning-Making: A Dialogic Response

2.2.1 A Research Framework: Aim and Purpose

The collaborative research of Eduardo Mortimer and Phil Scott integrates their shared interest in science education and sociocultural theory of learning (Mortimer and Scott, 2000; 2003; Scott, Mortimer and Aguiar, 2006). Their research focuses on the social interaction between teachers and learners in science classrooms. Observing teachers and science classrooms in the UK and Brazil, they identified how teachers adopt a more ‘presentational style’, representing the ‘taken-for-granted’ nature and role of classroom talk. However, their approach to classroom research identified different types of classroom ‘talk’ manifesting across an entire teaching sequence. Identifying these various forms of classrooms allowed them to understand the role of ‘talk as being central to the meaning making process and thus central to learning.' (Mortimer and Scott, 2003, p. 3). Thus, a significant feature of their research lies in addressing the relationship between meaning-making[3] and learning by bringing the role of classroom talk into greater prominence.

Spanning over a decade, their research led to the development of an analytic framework that captures and characterises the talk within science classrooms. Mortimer and Scott's framework is 'offered both as a tool for thinking about and analysing science teaching after the event and as a model to refer to, *a priori*, in thinking about the planning and development of science teaching.' (Mortimer and Scott, 2003, p. 25). As a research 'tool for analysing meaning making in science classrooms' (Scott, Mortimer and Aguiar, 2006, p. 609), it captures the social and linguistic dimensions of classroom interactions, or 'meaning making interactions' (Scott and Mortimer, 2005). Here onwards, I refer to Mortimer and Scott's analytic framework, as the 'meaning-making framework' (Criswell, Ruston and Shah, 2020) abbreviated to 'MMF'. This research framework aims to make visible the central role classroom '*talk*' plays in teaching and learning science. In turn it illuminates the 'link between talking, meaning making and learning' (Mortimer and Scott, 2003, p. 3) in science classrooms. In short, the framework offers a tool for analysing classroom talk and planning science lessons to support student learning.

In developing their meaning-making framework (MMF), Mortimer and Scott take inspiration from American educational psychologist James Wertsch and his *sociocultural* theory. They draw on his Anglo-American scholarship of Soviet thinkers, such as Vygotsky and his theory of learning and development and Bakhtin's semiotics, which inform their theoretical orientation on issues of mind, language and

[3] Mortimer and Scott employ the term 'meaning-making' in its unhyphenated form. However, in common usage and as employed by Bruner and Derry, the term is used in its hyphenated form. Throughout this thesis I use the term in its hyphenated form. Where it appears unhyphenated, it indicates Mortimer and Scott's usage, approach or viewpoint.

meaning. According to Mortimer and Scott, Wertsch's sociocultural theory offers a 'set of fundamentally important tools for thinking and talking about science teaching and learning.' (2003, p. 118) and underpins their analysis of classroom talk. I discuss their sociocultural perspective in more detail in the next chapter, following a demonstration of the application of this analytic framework below. Their sociocultural approach to analysing classroom talk offers innovative avenues for classroom research, responding to the problem of meaning-making in science classrooms, and promoting meaningful science learning through teacher-student dialogue. As I present their meaning-making framework (MMF), Mortimer and Scott consider their contribution to 'thinking and practice in three related areas' (ibid., p. 5):

1. *Teaching and learning science*:
    a. describing and illustrating the diverse range of teaching interactions in science classrooms
    b. demonstrating and exemplifying the ways in which language underpins science learning in the classroom
    c. showing how these ideas can be drawn upon to inform the professional development of science teachers.
2. *Research methodology*: developing a new socioculturally grounded approach to analysing classroom talk.
3. *Sociocultural studies*: expanding how sociocultural theory can be applied systematically to classroom contexts.

(adapted from Mortimer and Scott, 2003, p. 6)

These interrelated areas outline the critical contributions of MMF and broader themes around which the framework has been organised. According to Mortimer and Scott, these key themes are related to 'theoretical frameworks, analytical approaches and practical insights' (ibid., p. 5), which provides a framework for orientating one to various aspects of the MMF. In the remaining sections, I introduce and explain the multi-levelled structure of the meaning-making framework, which describes and characterises science teaching practice. I draw on a particular study that reports on primary science, demonstrating how various aspects of the framework offer an analysis of classroom talk. It illustrates Mortimer and Scott's approach to researching science teaching and their *dialogic* response to the pedagogic challenge of meaning-making presented above. As I discuss the insights of MMF here, I set the stage for a systematic comparison with an inferentialist approach derived from Derry's alternative philosophical scholarship of Vygotsky (see Introduction). In the following chapters (Chapters Four to Seven), the key themes: theory, analysis, and practice, orientate my research inquiry and development of my thesis.

2.2.2 A Multi-levelled Analytic Framework: Science Classroom Discourse

Mortimer and Scott (2003) seek to capture and characterise classroom talk by analysing teacher and student interactions[4] during science lessons. The meaning-making framework represents 'the various ways in which the teacher acts to orchestrate the talk of science lessons in order to support student learning.' (ibid., p. 6) [5]. The framework attends to three aspects of teaching – *focus*, *approach*, and *action*. Five aspects of analysis address different practical dimensions of teaching, as presented in the diagram below (Fig.1.).

[4] The analysis is also applicable to student-to-student interactions, but as my focus is on teacher-talk and whole class discussion, I have not focused on this aspect.
[5] As a planning tool for science teachers, it seeks to promote the 'meaningful understanding of scientific conceptual knowledge' (Scott, Mortimer and Aguilar 2006, p. 606).

Meaning-making Framework

	Aspect of Analysis	
(i) Focus	*1. Teaching Purposes*	*2. Content*
(ii) Approach	*3. Communicative approach*	
(iii) Action	*4. Teacher interventions*	*5. Patterns of interaction*

Fig. 1. (adapted from Scott, Mortimer and Aguiar, 2006)

Communicative Approach: The heart of the framework

At the heart of their framework lies the ‘communicative approach’, which addresses the different types of talk science teachers adopt in discursive interactions with their class (Mortimer and Scott, 2003; Scott, Mortimer and Aguiar, 2006). The *communicative approach* is an analytic approach, which provides a perspective on ‘*how* the teacher works with pupils to develop ideas in the classroom.’ (Scott and Ametller, 2007, p. 77 original *italics*). Central to this approach are two dimensions; the first addresses whether teachers *interact* with their pupils or not, and the second concerns whether teachers consider pupils' ideas in their interactions. Taken together, these dimensions offer four distinct classes of communication. I explain these dimensions below to understand these communicative classes better.

Interactive – Non-interactive Dimension: This dimension seeks to capture whether the teacher interacts with her pupils or not. For example, if the teacher opens up a discussion by asking a question and inviting pupils’ contributions, this would be an *interactive* approach. On the other hand, if the teacher adopts a lecture-style presentational approach to explaining a diagram or experiment and leads the classroom talk with very little discursive involvement from pupils, the approach is *non-interactive*. The interactive/non-interactive dimension captures the characterisation of the level of participation in classroom interactions. In classroom teaching and talk such distinctions are not always clear-cut. In view of the teacher's communicative approach, Mortimer and Scott conceptualise this distinction in terms of the teacher approach in allowing for participation (interactive) or excluding participation of others (2003, p. 34).

Dialogic – Authoritative Dimension: This second dimension does not depend on the number of people involved in the conversation but on characterising the talk according to the *range or diversity of ideas* in play. Such an approach would be illustrated if the teacher initiates the lesson by presenting a problem scenario using a resource such as concept cartoons[6], which offers several different perspectives or comments. The engagement of multiple ideas in these interactions is characterised as *dialogic*[7]. The term is to be understood as relating to a diversity of ideas or points of view, as opposed to the notion of a dialogue. Thus, the talk will often be characterised by following up 'that's interesting, what do you mean by that?' or 'Ok, so do you agree with that Andrea?', giving legitimacy and acknowledging the pupil's point of view or their *voice*[8] (Scott and Amettler, 2007). In a dialogic approach, there is always an attempt by the teacher to be inclusive of children's views to build a range of diverse ideas by attending to the points of view of both pupils and school science. Classroom talk is not always dialogic or inclusive of pupils' ideas. In the development of a lesson, the teacher may ask a question where she chooses to ignore pupils' ideas as they do not contribute to the development of the scientific

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[6] Concept cartoons are teaching resources or various topic or concepts that present different points of view illustrated through a cartoon characters and speech bubbles. See Keogh and Naylor (1999) for further details.
[7] The basis for this distinction draws on details related to sociocultural theory, which I reserve for more detailed consideration in the next chapter, where I discuss the theoretical underpinnings of the framework (Chapter Three).
[8] This is a technical sociocultural term, derived from Bakhtin's semiotics.

story. Their ideas may be excluded or reshaped in relation to the focus of the lesson. This form of classroom talk is characterised as *authoritative*. Consider a situation where the teacher initiates a discussion about the scientific concept of 'force' or 'weight'. She may adopt a more closed approach to classroom talk or questioning[9] , focusing on a narrow set of responses related to school science. Although this does not necessarily preclude her from being open and inclusive in her interactions with pupils. Her approach to classroom talk attempts to establish a singular focus – the scientific point of view and is identified as *authoritative* in approach.

Four Classes of Communicative Approach

These two dimensions generate four basic classes of communicative approaches, as illustrated in the table below. These four classes capture and characterise classroom 'talk' and the science discourse across an entire teaching sequence. Mortimer and Scott use these communicative classes in describing and differentiating the approach teachers adopt in their interactions with pupils.

Four Classes of Communicative Approaches

	Interactive	Non-Interactive
Dialogic	**A** interactive/dialogic	**B** non-interactive/dialogic
Authoritative	**C** interactive/authoritative	**D** non-interactive/authoritative

Fig. 2 (adapted from Scott and Ametller, 2007)

In sum, the communicative approaches can be stated in practical teaching terms as follows:

[9] This approach is referred to as a triadic pattern, which relates to the Initiate, Response and Evaluation (IRE) patterns of discourse. I discuss the historical development of classroom talk research and patterns of discourse in more detail in the next chapter (See Chapter Three, §3.1).

Table 1. Description of Communicative Approaches (adopted from Scott and Ametller, 2007)

Communicative Approach	Description of Approach
A. *Interactive/dialogic*:	Teacher and pupils consider a range of ideas.
B. *Non-interactive/dialogic:*	Teacher reviews different points of view.
C. *Interactive/authoritative:*	The teacher focuses on one specific point of view and leads pupils through a question-and-answer routine to establish and consolidate that point of view.
D. *Non-interactive/authoritative:*	Teacher presents a specific point of view.

Below, I demonstrate the analytic application of these communicative approaches to a primary science classroom. I have selected a study by Scott and Ametller (2007) reported in *School Science Review*, which addresses pedagogic insights that follow analysing a teaching sequence on the concept ‘forces’. I would like to emphasise that, although the communicative approaches offers an innovative conceptualisation and approach to analysing discourse, which sits at the heart of the meaning-making framework, it does not by itself constitute the full analytic capacity of the framework. As it forms the core concept of the framework, I consider it sufficient, at this juncture, to provide an initial orientation to two key themes of MMF, namely the analytical approach and pedagogic insights. The analysis of this teaching sequence offers a practical application of the MMF in response to the meaning-making challenge and its practical implications for science teaching.

2.2.3 Demonstrative Analysis of Primary Science Teaching

The scenario presented below is set within a primary school in rural England, involving a Year 6 class and a primary teacher with 20 years of experience (Mrs Simon). The teaching sequence introduces the scientific concept of ‘force’. It covers two lessons, presented as four episodes. I demonstrate the communicative approach analysis of this teaching sequence. I begin with a summary of the four episodes:

- Episode 1: What do you understand by the word ‘force’?
- Episode 2: Looking at the meaning of the word ‘force’.
- Episode 3: Is it scientific or not?
- Episode 4: What are forces?

Episode 1: ***What do you understand by the word ‘force’?:*** Mrs Simon (teacher) initiates the lessons with a whole-class discussion on forces. She invites pupils to offer their own ideas on the word ‘force’. This first episode illustrates how the teacher discusses what they think the word ‘force’ means. During this episode, Mrs Simon calls on pupils to voice their ideas, seeking their own ideas. The teacher makes explicit her openness and inclusivity of all and any ideas that may come to mind and not just science, by claiming, “Not just in science ... ’cos you are not always using it in a scientific way.” (Scott and Ametller, p. 79). Mrs Simon acts as a scribe with a flipchart, collating pupils’ ideas with little comment, feedback or interference, whether pupils’ comments are related to science or not. In this episode, the interaction involves many participants (interactive) and many ideas (dialogic), and so the communicative approach is classified as:

- **Episode 1:** *Interactive / Dialogic Approach*

Episode 2: ***Looking at the meaning of the word ‘force’:*** Pupils review three dictionary definitions for the term ‘force’ from two different dictionaries; thus, the activity involves different points of view, even if not voiced by the pupils themselves. The term dialogic[10] is employed to account for different points of view, while pupils contributions may well be closed off. Instructing pupils as she works through the activity sheet with multiple definitions of ‘force’, she adopts a more *non-interactive*

[10] This a Bakhtinian idea of dialogic, which are *voices* even if not voiced by an interlocutor. In this sense texts or dictionary definitions are also considered voices. I keep the analysis presented here simple and reserve discussion about discourse, speech and voice for Chapter Three and Four and are critical discussed in Chapter Six.

approach. The interaction in this episode is limited to the teacher (non-interactive), although multiple ideas are in play (dialogic); therefore, the communicative approach is classified as:

- **Episode 2:** *Non-Interactive / Dialogic Approach*

Episode 3: *Is it scientific or not?:* Mrs Simon sets up table groups to discuss and determine whether certain uses of the term 'force' are scientific or not. Each table receives sentence statement cards that employ various uses of the term force, phrases such as 'force the door open', 'force of habit', and 'force of the storm'. These are used to initiate small-group discussions around using the term 'force'. Mrs Simon facilitates during the plenary session, where each table reports on points of agreement and disagreements within their groups regarding the different 'force' statements.

In contrast to the first episode where the teacher invited all ideas, she prompts pupils to contribute to the discussion by asking, 'do you agree with that?', 'what do others think?', or 'so you disagree with what they say?'. A whole-class discussion[11] focuses on what constitutes the scientific use of the term 'force', which focuses on the scientific point of view as opposed to pupils' everyday views[12]. Mrs Simon prompts children to speak up and discuss their ideas but refrains from actively providing feedback. The conversation involves different points of view, although directed by the teacher towards more scientific ways of talking or scientific discourse. Whereas the first episode functions at the level of everyday discourse, the classroom

[11] This relates to the focus aspect of teaching in the MMF, which determines the content of the classroom talk. In this episode the focus is on the scientific, but still involves range of views or voices, thus is dialogic in nature though focus remains on the scientific ways of speaking.
[12] This draws on Vygotsky's conception of everyday / scientific concepts or discourse, presented in his Thought and Language.

discussion here aims to move pupils towards scientific discourse. Thus, a diversity of views remains in the classroom talk (*dialogic*), although the focus is directed toward scientific ways of talking. The lesson concludes with an outdoor activity. Sports equipment and scientific phrases are used to describe push-pull and stop-start actions. The interaction involves the pupils and teacher (interactive), while multiple ideas are involved and not limited or restricted to scientific ones (dialogic). The communicative approach in this episode is classified as:

- **Episode 3:** *Interactive / Dialogic Approach*

Episode 4: ***What are forces?:*** Mrs Simon starts the lesson by reviewing what the children did and learnt in the last lesson by asking, 'what are forces?'. The pupils respond by adhering to the classroom 'ground rules' (Mercer, 2008; Mercer, Dawes, and Staarman, 2009) by raising hands whilst the teacher nominates. What ensues is an extended whole-class dialogue exhibiting a clear sense of turn-taking (Edward and Westgate, 1994; Mehan, 1979; Mortimer and Scott, 2003) with an active role by the teacher in providing feedback or evaluation (Mortimer and Scott, 2003), which was absent in the first lesson. Unlike in previous episodes, the teacher actively guides the classroom discourse. Her communicative approach is markedly distinct. Scott and Ametller (2007) refer to this shift in approach from episode 3 to episode 4 as the *turning point*. I discuss this 'turning point' in the next section. For now, I address classifying the communicative approaches.

In contrast to earlier episodes, the teacher seeks specific answers to questions driven by a clear learning intention. This leads to the teacher 'closing down' discussions instead of earlier forms that sought to open them up. The teacher's focus in directing the discussion focuses on the concept of forces from the scientific point of view. Mrs Simon, in bringing the class discussion to a conclusion, talks to her class to make explicit the scientific view of ‘forces’. In concluding the class discussion and the lesson, she adopts a plenary-style closure, offering an evaluative statement. She uses a ‘we’ voice to review what they have learnt about the scientific concept of forces and relates this explicitly to the next lesson for her pupils, which involves investigating ‘direction’ and ‘measurement’ of ‘forces’. In the final part of this episode, there is a change in approach regarding the level of participation. Whereas the discussion begins with the involvement of all pupils (interactive), it ends with the teacher leading with her pupils listening (non-interactive). In contrast to previous episodes, which saw a range of different ideas or points of view (dialogic), here it was directed by a single view, namely the scientific ways of talking and thinking about ‘forces’ (authoritative). Thus, the communicative approach is classified into two parts:

- **Episode 4a:** *Interactive / Authoritative Approach*
- **Episode 4b:** *Non-interactive / Authoritative Approach*

2.2.4 Communicative Approach Analysis: Making Classroom Talk Visible

The characterisation of classroom talk into four classes of communication[13] or *communicative approaches* offers an innovative approach for analysing the dynamics of classroom interactions and understanding meaning-making in science classrooms. The power of their analytic framework lies in making visible what they refer to as the ‘invisible’ nature of science classroom talk’ (Mortimer and Scott, 2003, p. 2). For example, Mortimer and Scott report a student-teacher observing an experienced teacher who claims: ‘...I know she’s a real expert. I just couldn’t put my

[13] Interactive/ Dialogic, Interactive/ authoritative, Non-interactive/ Dialogic, and Non-interactive/ Authoritative. Please see page 41-42, for explanation.

finger on what she was doing that made it all fit together so well.' (ibid., p. 67). The student-teacher cannot see the 'various ways in which the teacher acts to orchestrate the talk of science lessons in order to support student learning.' (ibid., p. 6). The meaning-making framework (MMF) offers an approach to capture and characterise how expert science teachers orchestrate classroom talk. As a result, the analysis provides a detailed and systematic analysis of the lesson sequence, making distinctions that make the nature of classroom talk visible. The MMF has endowed the science education research community with a tool that illuminates specific changes that occur over a teaching sequence, providing insights into teaching and learning and subsequently offering teachers a resource for thinking about science teaching. How the framework analysis captures such changes in classroom talk across a teaching sequence is illustrated in the diagram below (Fig.3):

<u>Key Episodes in the Teaching Sequence</u>

• Episode 1: What do you understand by the word 'force'?	Interactive/Dialogic
• Episode 2: Looking at the meaning of the word 'force'	Non-interactive/Dialogic
• Episode 3: Is it scientific or not?	Interactive/Dialogic
• Episode 4: What are forces?	(a) Interactive /Authoritative (b) Non-interactive/Authoritative

<u>Science Teaching of 'forces': Communicative Approach Analysis</u>

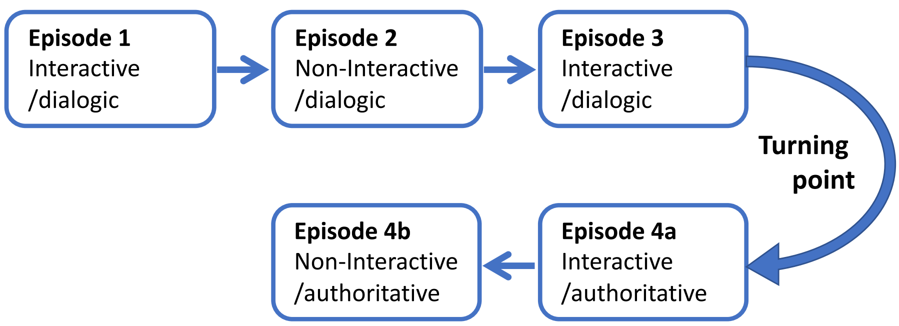

Fig. 3. (adopted from Scott and Ametller, 2007)

In brief, the diagram shows how the first three episodes in the teaching sequence share the feature of being *dialogic.* These are phases where the teacher seeks to ‘open up’ the classroom talk by engaging with a diverse range of ideas about forces, which at the beginning includes pupils’ own or everyday points of view (Episode 1: ‘their understanding of forces’) and later focuses on pupil’s own scientific ideas (Episode 3: is it scientific or not). In this sequence, all but the final episode involved some form of teacher-pupil interaction that was *dialogic.* Only in the final phase (Episode 4: what are forces?) does the teacher adopt an *authoritative approach* that aims to ‘close down’ the classroom ‘talk’, focusing on the scientific point of view. At this stage, the teacher's aim and intention are to develop the scientific story about forces and the scientific ways of talking and thinking about them.

2.3 Meaning-Making in Science Classrooms: A Sociocultural Approach

Following the differentiation of four communicative approaches, the issue remains how this analysis informs teacher practice in teaching science. Mortimer and Scott’s response involves discussing the ‘turning point’ illustrated in the teaching sequence and the nature of such changes between communicative approaches.

2.3.1 Rhythmic Patterns in Teaching Sequences

Mortimer and Scott developed their analytic framework informed and inspired by sociocultural theory. From this perspective of mind and learning, they consider the role of science teaching as enabling ‘students to move from an everyday view of a physical phenomenon to a scientific one.’ (Scott, 2008, p. 17). The communicative analysis provides an organised and structured representation of how science teachers ‘*start with the student’s everyday ideas,* and move from those ideas to the scientific point of view.’ (Mortimer and Scott, 2003, p. 48). For example, learning about ‘forces’ involves pupils discussing ‘perceptual evidence and diagrams’ and coming to 'reject an everyday account in favour of a scientific one.' (Scott, 2008, p. 17*).* The teacher's success depends on both 'domain-specific scientific knowledge and on their skill in managing different modes of talk appropriately' (ibid*.*), where science teaching and learning involve an induction into the *social language of school science* (Mortimer and Scott, 2003).

During a teaching sequence, there are points where the science teacher needs to intervene and introduce specific new ideas to the class, making them available on the *social plane* of classroom talk (Mortimer and Scott, 2003, p. 9; Scott, Mortimer and Aguiar, p. 608). For example, regardless of how much a child thinks about a problem or engages in a practical activity about 'force', 'condensation' or 'hardness'[14], they do not simply 'discover' or grasp the scientific meaning of such terms, if left to their own devices. As Mortimer and Scott state:

> …if students are to learn the social language of science, then somewhere within the teaching and learning performance there must be an authoritative introduction to the scientific point of view. Students will not stumble upon, or discover, the key concepts of the social language of science for themselves. (2003, p. 106).

Simply put, there are times in teaching science when the teacher adopts a more presentational and authoritative approach in introducing and explaining the science and the meaning of scientific terms involved. The 'turning point' illustrated such shifts in teachers' pedagogic or communicative approaches (see Fig.3, p. 49). The first three episodes show the initial *opening up* phase (dialogic) leading into the *turning point*, where the teacher pivots to adopt an *authoritative* approach (episodes

[14] Resistance of a material to deformation, indentation or penetration.

4a/b). After the turning point, the classroom interaction and teaching purpose turn to a singular focus on presenting the scientific view of the target concept ‘forces’. This shift involves turning from a *dialogic* approach to talking open to pupils’ points of view towards an *authoritative* approach, where such *dialogic* interactions are ‘closed down’. These shifts and changes are not incidental. The analysis represents certain communicative patterns that ‘points to a pedagogy which is based on purposeful shifts in a communicative approach as everyday and scientific views are juxtaposed and the scientific view is applied in different contexts.’ (Scott, 2008, p. 35). Mortimer and Scott draw on extensive observations of classroom interactions in claiming that certain distinctive *communicative patterns* emerge from their sociocultural analysis of classroom talk.

During a teaching sequence, there is a ‘progressive transformation of content’ (Mortimer and Scott, 2003, p. 71); a move from everyday ways of thinking and talking to a more scientific approach. Their communicative analysis of teaching sequences has displayed rhythmic patterns or repeated cycles, leading them to suggest a kind of *teaching rhythm*[15] present in teaching and talking in science classrooms. However, Mortimer and Scott are careful to stress that the framework is not a prescriptive mechanism or algorithm that assists teachers in formulating teaching sequences. The framework aims to demonstrate that ‘in *any* teaching sequence there *should* be a variation in classes of communicative approaches’ (Mortimer and Scott, 2003, p. 72) and that ‘part of the science teacher’s role is to strike an effective balance between *dialogic* and *authoritative* communicative approaches.’ (ibid., p. 107) in teaching science and classroom talk. Understood in

[15] Mortimer and Scott draw inspiration from the book ‘Explaining Science in the Classroom’ by Ogborn, Kress, Martins and McGillicuddy (1996) which introduced the ideas of ‘Orchestrating’ and ‘rhythm’ in science teaching (p. 16).

this manner, the communicative patterns illuminate how experienced teachers orchestrate classroom talk and approach a science teaching sequence.

2.3.2 Teaching Cycles and Developing the Scientific Story

The notion of ‘communicative approach’ that forms one of the aspects of the framework, provides an analytic tool for teachers to think and reflect on their lesson planning and ways to incorporate more *dialogic* forms in their classroom interactions. Distinguishing between everyday and scientific languages’ role in progressively *transforming* students’ ideas may help teachers better grasp the significant role ‘classroom talk’ plays in science teaching. In addressing multiple aspects of teaching science, the framework also acknowledges the role of the teacher in ‘making the scientific story available, and in supporting students in making sense of that story.’ (Mortimer and Scott, 2003, p. 25). So how do the rhythmic changes of the ‘progressive transformation’ of content and ‘teaching cycles’ represented by communicative approaches analysis fit with the development of the scientific story and teaching performance?

In bringing this demonstration to a close, I address how communicative patterns inform and illuminate teaching in developing the scientific story. The communicative approaches correspond to three phases in developing the scientific story: (i) Exploratory phase; (ii) Working-on phase; (iii) Review phase. Although Mortimer and Scott identify these teaching phases, they take caution to warn that ‘[w]e are not arguing that there should *always* be such a direct relationship between purposes and approach. Teaching never works out in that precise, predictable kind of way in practice’ (Mortimer and Scott, 2003, p. 103 *italics* in original).

Exploratory Phase: Developing the story is closely associated with the *Interactive/Dialogic* approaches. It involves interacting with pupils in an inclusive, open, or non-restrictive manner (*dialogic*). In the first lesson in the 'forces' sequence[16] (Episode 1), the teacher's purpose was to 'explore students' ideas', which opened up the topic and teaching sequence.

Working (-on) Phase: This is associated with *Interactive/Authoritative* approaches. During this phase, 'it is the teacher who has the responsibility for introducing and leading the development of the scientific story.' (Mortimer and Scott, 2003, p. 70). For example, in Episode 4a (What are forces? see Fig.3 p. 49), the teacher interacts with her pupils, but in contrast to previous approaches, her approach is relatively closed, narrowly focused and largely teacher-led. Her focus lies in 'working on' their scientific ideas supporting pupils to grasp scientific ways of talking and understanding the problem[17] as she develops and guides the classroom talk towards the school science point of view. We saw this phase initiated in Episode 3, where the teacher's focus was on exploring pupils' ideas and the teacher's approach reflected an emphasis on a dialogic approach (I/D).

Review Phase: This third and final phase is associated with *Non-Interactive/Authoritative* communicative approaches. In this phase of the teaching sequence, the teacher assumes full authority over the classroom talk. She brings the conversation to a final close. The teacher can draw a line under all foregone interactions, whether *dialogic* or *authoritative*. As part of a non-interactive exchange,

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[16] See Fig. 3., p. 50; Episode 1 what do you understand by the word force?

[17] In this scenario or a follow up episode the 'teacher monitors process, intervening as appropriate to provide help in supporting individual meaning making and internalization' (Mortimer and Scott,2003, p.69)

she initiates and evaluates the claims made in an attempt to review and summarise the state of affairs and what has been discussed in relation to the scientific story. She summarises how far they have developed with regard to what has been taught, the teaching sequence and what will happen next. According to Mortimer and Scott, the exchanges during this phase tend to involve a ‘we’ voice to provide a basis in which a *shared understanding* (Edward and Mercer, 1987) is recognised, acknowledged and suggested, bringing this particular teaching cycle to a close.

The teaching sequence on ‘forces’ served to illustrate how the MMF illuminates the challenge of meaning-making by attending to the communicative approaches (classroom talk) on the one hand and the development of scientific discourse (developing the scientific story and language of school science) on the other. The analysis demonstrates how the teaching sequence moves through all four communicative approaches, which move through three phases, from everyday language to the social language of science. In this particular sequence, the teaching rhythm covers a single teaching ‘cycle’ (see Fig. 4.), though an extended sequence may involve multiple cycles. In the ‘force’ teaching sequence illustrated above, Mrs. Simon covers all three phases: exploratory, working-on and review, as she introduces, maintains and develops the scientific story concerning pushes, pulls and direction (see Table 2. below).

Table 2. Phases of Developing Scientific Story

Exploratory Phase:	*Working (-on) Phase:*	*Review Phase:*
Episode 1: 'What do you understand by the word force?' **Episode 2:** 'Looking at the meaning of force' **Episode 3:** 'Is it scientific or not?'	**Episode 3:** Is it scientific or not? **Episode 4a:** 'What are forces?'	**Episode 4b:** 'What are forces?'

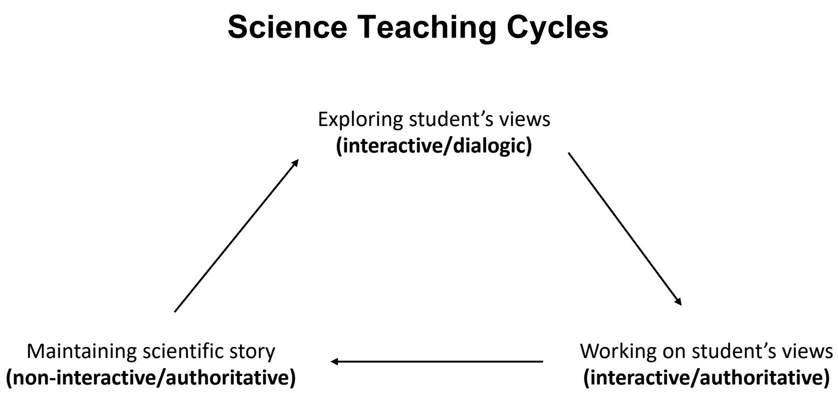

Fig. 4. Communitive patterns as teaching cycles

Scott and Ametller's (2007) primary science teaching sequence offers a helpful initial orientation to the analytical and practical implications of MMF and the communicative approach analysis. I have elaborated on their account by addressing rhythmic patterns and teaching cycles, illuminating the 'dialogic' nature of teaching science. Mortimer and Scott understand science teaching and learning in relation to the way 'meaning making always involves bringing together, and working on, different ideas, and is therefore *dialogic* in nature' (2003, p. 106). In teaching science, this involves engaging children in comparing and contrasting a range of views and introducing the scientific points of view to support learners to move from everyday towards more scientific ways of thinking and talking that allows them to make sense and appreciate the scientific story and perspective that underpins the teaching sequence, conceptual content and classroom talk.

Mortimer and Scott consider their analytic framework as ‘providing a set of fundamentally important tools for thinking and talking about science teaching and learning.’ (p. 118). In recognising and illuminating the significance of classroom talk, they acknowledge that in practice, ‘there will always be a tension between dialogic and authoritative discourse’ (Mortimer and Scott, 2003, p. 106). A more *dialogic approach* to science teaching lies not in adopting a single approach but in recognising the role different forms of classroom interactions and discourses play in an effective teaching sequence. A critical insight of MMF lies in alerting teachers to their role in striking an effective balance between dialogic and authoritative communicative approaches (Mortimer and Scott, 2003; Scott and Ametller, 2007). Teaching for a practical, meaningful understanding of science and scientific concepts involves a teaching performance that uses all four communicative approaches, cycling through all of them as required; the interaction arises and unfolds over an entire teaching sequence.

2.3.3 Towards a Resolution or a Problem Deferred?

The demonstration of Mortimer and Scott’s analytic approach illustrates their sociocultural response to the challenge of meaning-making in science classrooms. However, developing the MMF as an analytical tool highlights a much broader problem within science education research and science teaching. Following over a decade of observing science classrooms and teaching, they claim ‘lots of the science lessons that we see in schools are limited in terms of the kinds of teacher-student interactions, and that by far the most common is the interactive/ authoritative approach.' (Mortimer and Scott, 2003, p. 110). In other words, science teaching is dominated by a reliance on a presentational style or instructional approach. They argued, in tackling the issue of science teaching for meaningful understanding, the priority in research must first be to make existing classroom teaching practices more 'visible' (ibid., p. 5). This is the aim of their analytic framework, to capture and characterise the key features of talk in science classrooms. In adopting this analytic approach, the MMF seeks to extend previous research by offering 'a more integrated and comprehensive approach to capturing and characterizing the talk of school science' viewing learning and the meaning-making process as essentially *dialogic* in nature (Mortimer and Scott, 2003, p. 4). However, as Scott, Mortimer and Aguiar (2006) acknowledge '[d]espite this widespread interest in dialogic discourse, the fact of the matter is that dialogic interactions are notably absent from science classrooms around the world (Alexander, 2001; Fischer, Reyer, Wirz, Bos, and Hollrich 2002; Wells, 1999).' (p. 606)[18]. However, almost two decades since the inception of their framework, and over forty years of classroom talk research, the issues of dialogic discourse continue to be discussed by researchers (Mercer and Dawes, 2014), with some like Howe and Abedin (2013) claiming. '…given an essentially static situation over 40 years... arguably the characterization of dialogic patterns should not be accorded high priority when it comes to future research'. (p. 344). Thus, the problem of communicating science concepts for meaningful understanding remains a stubborn issue. I propose that a better understanding of the nature of this challenge

[18] In fact, they extend their comments by referring to the dialogic discourses Mortimer and Scott present in their book (2003), as '(rare as they may be)'.

can be attained in light of a deeper exploration of the framework's theoretical underpinnings, an issue I will discuss in the next chapter. Mortimer and Scott view classroom talk and social interactions through a sociocultural lens. They develop an innovative approach to the meaning-making problem that simultaneously makes visible the role both *classroom talk* and the *scientific discourse* play in teaching and learning science. To fully appreciate the pedagogic implications of the communicative approach in teaching and learning science and the reflective tool it offers teachers in professional development, we need to better understand the theoretical roots that inspired and underpin their framework. In the next chapter, I review the historical context in which their framework was forged and the sociocultural theory that inspired its development. Of particular interest here is the Soviet thinker Vygotsky and subsequent post-Vygotskian approach, through which a better understanding of their theoretical perspective, research methodology and practical insights can be gained. The central themes provide a strategic context for examining critical challenges to post-Vygotskian scholarship and as an entry point for introducing alternative scholarships and their relation to the emerging theory of inferentialism. This sets the scene for Chapter Four, where I initiate a systematic deconstruction of the meaning-making framework and argue that the view of meaning-making presented above and reviewed historically and theoretically in the next chapter may be far from being resolved.

3 Investigating Meaning-Making: A Sociocultural Approach

In this chapter, I review the theoretical and methodological underpinnings of Mortimer and Scott's analytic framework. As I explore the genesis of their multi-levelled analytical framework, I discuss its emergence rooted in integrating two historically distinct strands in educational research: classroom communication and concept development[19]. The first strand relates to linguistics and sociology, where studies focus on social interactions and classroom talk between teachers and students, giving rise to classroom talk research (Barnes, 1976; Mehan, 1979; Mercer and Dawes, 2014). The second strand relates to developments in the field of psychology in education and science classroom research (Scott, Asoko and Leach, 2007). As I examine the historical research context in developing their framework, I identify key assumptions rooted in their methodological and theoretical commitments. This review addresses the following areas: i. theoretical orientation, ii. analytical approach to classroom discourse, iii. practical and pedagogic implications. In concluding this chapter, I raise emerging challenges to sociocultural theory, the MMF's research methodology and pedagogic studies employing dialogic approaches. These issues offer a crucial entry point for introducing emerging and alternative research perspectives concerning Derry's philosophical Vygotsky scholarship. This emerging and alternative scholarship's theoretical and methodological considerations are addressed in the next chapter. However, to better understand such implications, I first turn to the historical context to situate the MMF's contribution to both strands of classroom research.

[19] It is noteworthy that these two distinct strands of research serve as two integral but non-dual aspects in presenting my inferentialist thesis. This is reflected in a focus on concept development in Chapters Four and Five. This is complemented by a focus on communication in Chapters Six and Seven.

3.1 Science Education Research: Classroom Talk to Meaning-Making

3.1.1 Classroom Research: A Historical Context

Research on classroom talk has been an active field of research for over forty years (Mercer and Dawes, 2014). Since the 1970s, significant transformations have occurred in classroom talk research (Hodgkinson and Mercer, 2008). Before the 1970s, there was little evidence of verbatim transcripts (Edwards and Westgate, 1994; Mercer and Dawes, 2014). However, qualitative research methods gained traction with the advent of affordable and portable recording technology and transcription of classroom data. Around the same time, in the wake of the Cold War, although Vygotsky was known in Western academia, English translations of Soviet thinkers such as Vygotsky and Bakhtin began to be widely available and distributed. Vygotsky's work brought together seemingly disparate fields such as linguistics, anthropology and psychology (Mercer and Dawes, 2014; Wertsch, 1985). This interdisciplinary move inspired an acute focus on classroom dialogue and the analysis of such talk. British linguists Sinclair and Coulthard (1975) analysed the teacher-student exchange by identifying the 'minimal unit of interactional exchange' (Mercer and Dawes, 2014, p. 432), which served as their *unit of analysis*. This exchange unit was expressed as the 'initiate- response- feedback' or referred to by the acronym 'I-R-F' (Mercer and Dawes, 2014; Sinclair and Coulthard, 1975). On the other side of the Atlantic, an equivalent notion was advanced by American sociologist Hugh Mehan (1979), who adopted the 'initiate, response and evaluate' sequence (I-R-E). As an example, consider the following exchange (Scott and Ametller, 2007):

Teacher: What are forces? Jessica. [Initiation]

Pupil: A push or a pull? [Response]

Teacher: Yeah! Pushes and Pulls [Feedback/Evaluation]

Where British linguists attended to the textual structure of spoken language in an exchange, American sociologist Mehan was more concerned with the *social contexts* in which such discursive interactions occur. The social context includes within its purview power relations or the social order belonging to the institutional environment of school classrooms (Lemke, 1990; Mercer and Dawes, 2014). Once these distinctive IRE patterns are recognised, they are hard to ignore (Lemke,1990). This was illustrated by Mortimer and Scott's development of their Communicative Approach analysis and the distinction between 'interactive' and 'non-interactive' dimensions in classroom talk, which was informed by IRE patterns. This aspect of their analysis is named 'patterns of discourse', forming part of their multi-levelled framework[20] (see Chapter Two).

From the 1980s into the 1990s, qualitative researchers became increasingly interested in how *context* influences *meaning* for interlocutors in classroom dialogue[21] (Edwards and Mercer, 1987; Edwards and Westgate, 1994). Subsequently, there was a shift in approach in classroom research away from linguistic toward pragmatic features of language-in-use. However, the extensive and habitual use of IRF/IRE exchanges within classroom research was becoming viewed in an increasingly critical light. The triadic dialogue (i.e., IRF exchanges) identified by

[20] Mortimer and Scott modify the discourse patterns by extending the IRE unit of analysis by contributing an additional category. See Chapter Seven for discussion.

[21] Research studies by Edwards and Mercer (1987) make evident their awareness of the significance of *context*, concerned not only with environmental or physical factors but also the historical and shared dimensions that manifest in the social activity of talk.

classroom research became associated with classroom practices involving ‘closed questions’ and teacher interrogation of students aimed at some correct answer. Consequently, in teaching practice there were attempts to minimise questioning and avoid such I-R-F forms of exchange or classroom talk (Wood, 1992, cited in Scott, 1998). However, Mortimer and Scott's (2003) analytic framework involves considering the pedagogic context of teaching purposes and science discourse. They illustrated how IRE triadic interactions or closed questions should be recognised in both research and practice as ‘an equally important and fundamental part of science teaching’ (Mortimer and Scott, 2003, p. 71; Wells, 1999; Nassaji and Wells, 2000).

Since the beginning of the 21st century, there has been growing interest in discursive approaches, and the term *dialogic teaching* has become widely adopted (Alexander, 2017). Neil Mercer and colleagues identified two significant contributors to the study of *dialogic teaching* (Mercer and Dawes, 2014; Mercer, Dawes, and Staarman, 2009). They first address Robin Alexander (2006), who introduced and elaborated on the term through his cross-cultural studies (2000; 2019). They identify Mortimer and Scott and their analytic framework (2003) as the second major contributor. Their pedagogic contribution lies in offering tools that identify *dialogic* approaches to teaching. They warn against privileging any single class of communication over another, advocating for *purposive* engagement with *all* forms of talking and teaching science. Teaching involves ‘*striking a balance’* (Scott and Ametller, 2007) according to the needs of the science content and teaching sequence (Mortimer and Scott, 2003). Mercer and Dawes, in speaking to developments in classroom talk studies, echo Mortimer and Scott’s point in acknowledging ‘it is the strategic balance that is important’, asserting that:

> For students to learn effectively, there will be times when they should sit quietly and listen to an authoritative explanation; but they are likely to develop a deeper understanding of a topic if they also have opportunities to express their own ideas, hypothesize, hear the thoughts of their fellow students, argue, reason and gain feedback from their teacher when 'thinking aloud' through a line of reasoning... (Mercer and Dawes, 2014, p. 438)

This historical context of classroom talk research acknowledges the role of MMF within this first strand. I turn now to trace developments within the second strand, namely science education. The focus on learning and teaching science shifts attention from the analytical issues of talk to that of concept development and meaning.

3.1.2 Discursive Turn in Psychology

In parallel with developments in classroom talk research informed by linguists and sociologists, there were fault lines and shifting grounds within educational psychology. During the 1990's educational researchers placed increasing emphasis on investigating the role of language and meaning in classroom conversations, referred to as the *discursive turn*[22] in educational psychology (Scott, 1998). The turn marks a significant shift within psychological research, away from studies that focus on individual cognitive processes on specific tasks towards approaches that consider individuals (learners) in relation to social contexts and classroom discourse in which they functioned (Scott, 1998; Bruner, 1990, 1996). The discursive turn was inspired

[22] Scott (1998) identifies Harrè and Gillet (1994) as coining the descriptive term 'discursive turn in psychology'.

mainly by the 'rediscovery of the work of Vygotsky[23] and other Soviet psychologists[24] of the sociocultural tradition.' (Scott, Asoko, Leach, 2007, p. 34) and paved the way for the emergence of *discursive psychology* (Scott, 1998). This emerging psychology stood in contrast to mainstream Anglo-American psychology, which adopted more compartmentalised or specialised approaches (Wertsch, 1985). An instrumental figure in this emerging field was Jerome Bruner (1990). Inspired by Vygotsky's work, he developed what he initially referred to as a 'culturally oriented psychology'. His critical history of psychology took issue with cognitive psychology, which adopted an information-processing model of the mind.

Contrary to psychological studies focusing solely on the individual, Bruner suggested an alternative 'cultural model of mind' (Bruner, 1990). Critical of the notion of 'information' and the computational analogy of mind, Bruner sought to displace it by restoring and re-establishing the central role of *meaning* in psychology. He viewed psychology as a field of study primarily concerned with *human* minds as opposed to cognitive processes. Bruner posited his cultural psychology as correcting the shift from '"meaning" to "information", from the *construction* of meaning to the *processing* of information.' (ibid*.,* p. 4). He viewed cognitive psychology as neglecting the role mind plays in the 'process and transaction in the construction of meanings' (Scott, 1998). In an attempt to counter the dominant notion of 'information-processing', in his cultural psychology, Bruner emphasises the term 'meaning-making'. In focusing on *meaning-making,* he proposed a study of the mind that acknowledged human culture and language's significant role in human development.

[23] It is important to highlight that when Mortimer and Scott and colleagues refer to Vygotsky's work, they do so interchangeably with the term 'sociocultural' as coined by Wertsch.
[24] It is important to note the term 'psychologist' as this seemingly trivial identification becomes crucial in my second part. I draw on Derry's work, which identifies Vygotsky and Piaget not as Psychologist but as Epistemologist.

The emergence of a ‘cultural psychology’ (Bruner, 1990, p. xiii) and the subsequent discursive turn that followed forged a ‘new direction’ in science education research (Scott, 1998, p. 46). Attention in classroom research studies subsequently turned from ‘individual student understandings’ to approaches that appreciated how ‘understandings are developed in the social context of the science classroom’ (Scott, 1998, p. 46). The upshot of this discursive turn was a revival of interest in teachers and their role in science classrooms, as opposed to learner-centred approaches (Scott, Asoko and Leach, 2007). The teachers’ role and responsibility in orchestrating classroom interactions in social and cultural environments were brought to the fore in science education research (Scott, 1998, Mortimer and Scott, 2003).

3.1.3 Science Classroom Research and Meaning-Making

Over the last 30 years, science education research has shifted its focus from individual cognition to understanding the role of social interactions and classroom discourse in influencing learning (Lemke, 1990; Mortimer and Scott, 2003). Following the discursive turn, research has focused on teachers, who take the lead in *controlling, managing and orchestrating the talk* in the science class (Mortimer and Scott, 2003). One of the quintessential problems Mortimer and Scott’s research identified was the neglected role of classroom talk in teaching science and social interactions. Their framework is a product of years of classroom observations that explored and sought to articulate links between meaning-making, talking and learning in science lessons (Scott, 1996; 1998; Mortimer, 1998; Mortimer and Scott, 2000; Mortimer and Scott, 2003). Critical to their research investigation was understanding classroom talk as ‘being central to the meaning making process and thus central to learning’ (p. 3). They were developing an integrated approach to analysis which involved both empirical research and a confluence of ideas from both classroom talk and science classroom research studies. Mortimer and Scott acknowledge four key influences on their research relating interactions with 'the ways in which meanings are developed through talk'. (2003, p. 4). These studies include:

1. Edwards and Mercer (1987) *Common Knowledge*, examines the relation between 'content of lessons and practical activities and the talk, which constitutes them.
2. Jay Lemke (1990) *Talking Science: Language, Learning and Values* 'proposes that learning science involves learning to talk science, and focuses on the question of *how* students learn to talk science through classroom discourse.
3. Ogborn *et al.* (1996) *Explaining Science in the classroom*, 'focus on the ways in which high school science teachers construct and present explanations in the classroom.
4. Kress *et al.* (2001) *Multimodal Teaching and Learning: The Rhetorics of the Science Classroom* 'explored the ways in which teaching and learning in the science classroom go beyond the spoken word to involve a range of different modes of communication.'

Taking inspiration from Soviet thinkers such as Vygotsky and Bakhtin, their research places emphasis on classroom talk (science discourse), interactions (social) and learning (individual) (Mortimer and Scott, 2000; 2003; Scott, Mortimer and Aguiar, 2006). In describing and analysing classroom discourse and social interactions, they take their lead from Anglo-American Vygotsky scholar James Wertsch and his sociocultural theory (Scott, 1998, p. 48). This sociocultural approach orientates their research approach to science teaching and learning and teacher-pupil interactions. Consequently, their research approach not only involves a shift from linguistics to pragmatics but also from *personal* meaning-making of the learner (Scott, 1996) to meaning-making in science classroom discourse and social interactions, referred to as '*dialogic meaning making'* (Mortimer and Scott, 2003, p. 12). In reviewing the historical challenges of researching classroom talk and meaning-making in relation to the discursive turn and sociocultural psychology, various frameworks have emerged to tackle the issues (Criswell, Rustin and Shah, 2020; Lidar and Östman, 2009; Tang, Delgado, and Moje, 2014; Wickman and Östman, 2002). So why does MMF take a central focus?

In short, Mortimer and Scott integrate two distinct research strands of classroom talk and science education into a single framework. Subsequently, it contributes not only to an analytic approach but also offers pedagogic insights and a planning tool for teachers. In recent years, however, this mainstream Anglo-American Vygotsky scholarship, including sociocultural theory, has come under increasing scrutiny. Emerging Vygotsky studies (Yasnitsky and Van der Veer, 2017; Toassa and Fernando Bonadia de Oliveira, 2018) and scholarship (Dafermos, 2018; Bakhurst, 2011; Blunden, 2012; Derry, 2013a; Roth, 2017; Zavershneva and van der Veer, 2018) are not only critical of such Anglo-American interpretations but by paying close attention to the Soviet context in which Vygotsky's work was generated, they offer alternative and contrasting perspectives. The philosophical reassessment of Vygotsky's corpus by Jan Derry is of crucial interest in developing the present thesis. A central contribution of her scholarship derives from restoring to Vygotsky his Hegelian heritage neglected by Anglo-American scholars and relating his work to contemporary developments in analytic philosophy and neo-Hegelian philosophers[25] (see Chapter Four, §4.1 for discussions). Her work is doubly pertinent here as she is not only critical of post-Vygotskian interpretation, focusing on Wertsch's sociocultural theory, but also draws on all four influences on MMF (see above). In offering this distinctive neo-Hegelian reading of Vygotsky, her work reorientates the concept of meaning (semantics) and issues surrounding meaning-making (pragmatics). A neo-Hegelian approach differs in that rather than seeking to integrate these two distinct strands of linguistics and pragmatics, it offers a theoretical orientation that views them holistically, thus negating the need for integration in the first place. However, this is a critical discussion I explore in more detail in the next chapter. These issues can be better discussed in light of theoretical and methodological commitments underpinning the MMF. With this aim in mind, I turn to consider the historical context in which MMF emerged and the influence of sociocultural theory on Mortimer and Scott's approach to investigating classroom talk and meaning-making research.

3.2 Meaning-Making in Science Classrooms: A Sociocultural Approach

In their seminal book *Meaning Making in Secondary Science Classrooms*[26], Mortimer and Scott identify 'key theoretical and methodological issues that frame the analysis presented in the book'. (2003, p. 119). They illustrate their analytic framework and sociocultural approach to researching meaning-making and investigating classroom interactions. Mortimer and Scott's meaning-making research

[25] Neo-Hegelian philosophers, refers to philosophers that adopt a contemporary reading of Hegel. They reinterpret his work by drawing on and bringing together the philosophical traditions of German Idealism, American Pragmatism and Analytic philosophy. For a more detailed discussion see Chapter Four, §4.1. on Pittsburgh School of Philosophy.
[26] As I review their main ideas, I heed their advice that ideas and material set within the appendices are 'aimed at those readers who wish to probe a little more deeply into some of the key ideas' (ibid).

framework (MMF) is firmly rooted in sociocultural theory. They take their lead from James Wertsch (1991), an American psychologist whose main field of competence lies in developmental psychology and semiotics. It was from his scholarship of Soviet thinkers, such as Vygotsky and Bakhtin, that sociocultural theory emerged (2003, p. 120).

In contrast to Western thinkers, Soviet thinkers adopted a more interdisciplinary approach (Wertsch, 1985). Inspired by their innovative approach to mind and meaning, Wertsch became increasingly critical of the specialisation and compartmentalisation trends prevalent in Western psychology as a field. He sought to develop an approach that would avoid the 'pitfalls of psychological research that focuses narrowly on the individual or on specific mental processes in vacuo'[27] (Wertsch, 1991, p. 5). In the wake of the discursive turn in psychology, he turned to issues of situated meaning-making instead of abstract cognitive processes. He considered Anglo-American psychology inadequate in responding to the social and cultural challenges critical to educational research. From this standpoint, he began thinking about how 'the voices of psychology and semiotics can come into productive dialogue with the voices of other disciplines' (1991, p. 5). Mortimer and Scott's analytic framework (MMF) subsequently reflects this theoretical move in bringing together different disciplinary perspectives. I turn to review Mortimer and Scott's perspective to illustrate how their approach to understanding and interpreting both Soviet thinkers – Vygotsky and Bakhtin, is underpinned by Wertsch's scholarship and his sociocultural perspective.

[27] Put differently, he focused on an approach to psychological issues that follows the linguistic turn in philosophy, which led to recognising the role and significance of cultural and social contexts.

3.2.1 Teaching and Learning Science: A Sociocultural Perspective

Mortimer and Scott's framework offers a unique sociocultural approach to analysing classroom discourse applied to science classrooms that sits in contrast to preceding approaches to classroom talk research. Wertsch offers his ringing endorsement[28] in referring to their framework as 'ground breaking' and as '…one of the best accounts we have to date of how sociocultural theory can be applied to classroom practice' (Mortimer and Scott, 2003, p. ix). As a framework integrating different research fields, they also bring together Vygotskian and Bakhtinian theories to bear on a research analytic approach. In this manner, MMF has served as a source of illumination for many science education researchers and educational researchers more broadly.

Lev Seminovich Vygotsky (1896-1934) is considered a Soviet psychologist. His fundamental idea is that 'development and learning involve a passage from social contexts to individual understanding' (Vygotsky 1978). From the outset, Mortimer and Scott place an emphasis on 'social contexts'. They understand this idea through Vygotsky's 'general genetic law of cultural development', which they cite as follows:

> Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category, and then within the child as an intra-psychological category. This is equally true with regard to voluntary attention, logical memory, the formation of concepts, and the development of volition. We may consider this position as a law in the

[28] Wertsch, makes these claims in writing the foreword to their book '*Meaning making in science classrooms'.*

> full sense of the word, but it goes without saying that internalisation transforms the process itself and changes its structure and functions. Social relations or relations among people genetically underlie all higher functions and their relationships. (Vygotsky 1931: 163 cited in Mortimer and Scott, 2003, p. 119)[29].

It is our participation in such social practices and modes[30] of communication in developing ideas and concepts that Vygotsky refers to as the *social plane*. Teaching and learning in science classrooms would exemplify the social plane. When the teacher introduces new ideas and concepts in classrooms, these new ideas develop and learning proceeds '[a]s ideas are rehearsed during the social event, each participant is able to reflect on, and make individual sense of, what is being communicated. The words, gestures and images used in the social exchanges provide the very tools needed for individual thinking.' (Mortimer and Scott, 2003, p. 9). Thus, talking, thinking and learning are part of an integrated process, '…a transition from *social* to *individual* planes, whereby the social tools for communication become internalized and provide the means for individual thinking.' (ibid., p. 10).

A key contribution to Anglo-American approaches to psychological and developmental studies lies in Vygotsky's account of the social origins of 'higher mental functions' of mind and learning. The social origins of mind and development played a pivotal role in the discursive turn in psychology, which Wertsch continues into his sociocultural psychology. According to Wertsch's reading of Vygotsky, our

[29] The term 'genetically' used by Vygotsky refers to genesis, origin and development , as opposed to the modern biological sense.
[30] This communication may take on a variety of modes, such as images, writing, talking, gestures or actions. It is useful to note that these 'modes' are all in Brandom's terms *representational* (for discussion see Chapter Four).

mental functions, such as ‘memory, attention, perception and thinking, *first* appear in an *elementary* form, as the result of a *natural* line of development’ (Mortimer and Scott, 2003, p. 119 *italics* in original). The idea of ‘natural’ is understood as biological development, so, while these elementary functions are acknowledged as formed in the course of natural or biological development, it is through ‘social interaction and participation in cultural life’ that such functions are ‘transformed to higher mental functions.’ (ibid., p. 120). For Vygotsky this transformation of higher mental functions is unique to human development. Following Wertsch (1985, p. 25), Mortimer and Scott highlight four criteria Vygotsky used to distinguish between elementary and higher mental functions:

1. The shift of control from environment to the individual; that is, the emergence of voluntary regulation.
2. The emergence of conscious realization of mental processes.
3. The social origins and social nature of higher mental functions.
4. The use of signs to mediate higher mental functions.

(Mortimer and Scott, 2003, p. 120)

In sum, from a sociocultural perspective, learning develops from the outside in, that is, it starts on the *social plane* involving a movement to the individual and formation of the *individual plane*. Learning is viewed as a process of *internalisation*. Consequently, Mortimer and Scott (2003) argue and act on the understanding that if one wishes to investigate ‘the ways in which people typically *think* about the world around them’ from a sociocultural perspective, then the starting point is an investigation of ‘the ways in which they *talk* and communicate about the world’ (ibid., p. 10). In developing an understanding of how learning occurs in science classrooms, their research focuses on ‘the talk and other modes of communication of science classrooms.’ (ibid.).

3.2.2 Sociocultural Theory and Post-Vygotskian Scholarship

In developing his sociocultural theory of mind[31], I read Wertsch as having two key stages. Firstly, he reads Vygotsky’s work as incomplete. Secondly, Wertsch recognises how Bakhtin as a Soviet semiotician, can be employed to extend and provide a complete and fuller account of mind and development, which he considers Vygotsky as having failed to provide.

Wertsch considers Vygotsky’s account of ‘the social origins of individual mental functioning’, the “genetic law of cultural development”’ (1991, p. 26) as one of his key contributions. Vygotsky’s approach to the nature of the mind and learning, which foregrounded human cultural and social interactions in theorising concept development, played a pivotal role in the discursive turn in psychology. Wertsch capitalises on his key contribution by extending it in developing his sociocultural psychology. While Wertsch recognises Vygotsky as an influential thinker and a significant source of inspiration, he raises several concerns regarding Vygotsky’s approach to studying the human mind and development. He notes that Vygotsky and colleagues typically used the term *sociohistorical* rather than *sociocultural* to refer to their work. In favouring the term *sociocultural* over its more cumbersome though admittedly more accurate term *socio-historical-cultural,* he claims that ‘failing to incorporate *cultural* into the title risks an even greater error, that of reducing cultural differences to historical differences, which is precisely what Vygotsky tended to do.’

[31] It is crucial to the next chapter that I highlight Wertsch’s sociocultural theory, which serves as the foundation for Mortimer and Scott’s conceptualisation of language, communication and meaning in teaching and learning science in school classrooms.

(Wertsch, 1991, p. 16). Wertsch claims that identifying this reduction to historical differences in his studies serves as a major distinction between Vygotsky's ideas and American anthropologists. In levelling this criticism against Vygotsky, he justifies labelling his own psychology as 'sociocultural' and as redressing Vygotsky's misdirected term 'sociohistorical' (Mortimer and Scott, p. 120). His sociocultural picture of Vygotsky has become mainstream, found in popular books referencing Vygotsky's development of innovative thinking in various research fields (Nisbett, 2005; Godfrey-Smith, 2017; Tomasello, 2009). However, his concerns run deeper than mere labels. Although deeply inspired by Vygotsky, he nevertheless adopts a critical reading of Vygotsky, which forms the foundation of his sociocultural project and post-Vygotskian scholarship, along with various other Anglo-American readings (Wertsch, 1985).

Vygotsky: A Psychologist in Crisis on the Nature of Meaning

Although Vygotsky only started a systematic study in psychology at the age of twenty-eight, he sadly died of tuberculosis at thirty-eight. Despite his short life, his works include *Thinking and Speech*[32](Vygotsky, 1987), which is considered the only book compiled by Vygotsky himself before his untimely death in 1934. Nonetheless, it has gained recognition as a classic foundational work of cognitive science. Wertsch adopts a critical reading of Vygotsky's *Thinking and Speech*, arguing that this work exhibits a certain ambivalence on the nature of mind and meaning as he struggled with 'multiple competing philosophical heritages' (Wertsch, 2000). Wertsch (1985, 1991, 2000) attributes this limitation to the influence of Enlightenment thought

[32] The English translation published in 1962 under the then title, *Thought and Language,* is considered one of the 'most important and influential books ever published by MIT Press' (Kozulin, 2012).

in Vygotsky's work. He reads[33] Vygotsky as subscribing to an Enlightenment position, derived from Descartes's epistemology, that takes a hierarchical view of rationality and development, holding abstract reasoning as an ideal – the 'pinnacle of thought' (Derry, 2008; 2013a), as the purpose of human development, 'its telos' (Wertsch, 2000). This approach to the study of mind and meaning as some inner mental operation, limited to psychology and semantic concerns, Wertsch considers symptomatic of Vygotsky's 'general philosophical perspective that he brought to his work.' (Wertsch, 1996, p. 34). He maintains that it was only towards the end of his life that Vygotsky realised that language, meaning, and rationality were 'sufficiently complex' (ibid.). Wertsch concludes this as the reason 'Vygotsky's writings reflect a kind of ambivalence with regard to where he stood on the ideals of Enlightenment rationality.' (ibid., p. 38). This late-in-life realisation challenged his Enlightenment commitment and led to the recognition of a different way of considering the operations of the mind and rationality. Furthermore, Wertsch argues that Vygotsky's untimely death is an all too often used justification that hinders acknowledging this limitation and condemns his project as incomplete.

Extending Vygotsky: Bakhtin's Pragmatic Contribution

Another influential figure is Soviet semiotician Mikhail Mikhailovich Bakhtin. Wertsch turns to Bakhtin and his ideas on language and semiotic analysis of dialogue as means to finish the job Vygotsky failed to complete (Wertsch, 1991). For Bakhtin, our *use* of language and words are never simply taken from books or dictionaries, that is considered as some abstract entity; rather, they are always taken from the *utterances* of others (Wertsch, 1991). Although text could also be included, Bakhtin

[33] Following Derry's reading, perhaps understood more accurately as he reads *into* Vygotsky this commitment.

viewed utterance as a 'process rather than a location' (ibid*.,* p. 51*)*. A key aspect for Wertsch is Bakhtin's examination of utterance, which focuses on 'situated action rather than on the objects that can be derived from analytic abstractions' (ibid*.,* p. 50). His approach identifies specific issues that plague 'many scholars of language, especially contemporary linguistics', namely their concern with 'linguistic form and meaning abstracted from the actual conditions of use'. (ibid*.*)*.* In redressing this issue, Wertsch claims 'Bakhtin focused his analytic efforts on the *utterance,* "the *real unit* of speech communication"' (ibid., p. 50, italics in original). Wertsch identifies this crucial aspect of his focus on *utterances,* as opposed to *linguistics,* expressed when 'Bakhtin wrote that "speech can exist in reality only in the form of concrete utterances of individual speaking people, speech subjects. Speech is always cast in the form of an utterance belonging to a particular speaking subject, and outside this form it cannot exist"' (1986, p. 71 cited in Wertsch, p. 50). However, Wertsch also highlights the way Bakhtin 'readily accepted the need to study "the specific object of linguistics, something arrived at through a completely legitimate and necessary abstraction from various aspects of the concrete life of the word"' (Bakhtin, 1984, p. 181, cited in Wertsch, 1991, p. 50). In this manner, acknowledging the role of studying linguistic objects such as words and sentences but also attending to their actual use in practice, his unit of speech communication applies to both written as well as spoken communication. (ibid*.,* p. 51). According to Wertsch, a key contribution by Bakhtin lies in his recognition that the linguistic focus on words and sentences as units in the analysis of speech, which remains abstracted from their actual use, and thus 'he argued that linguistics alone cannot provide an adequate account of utterances' (ibid*.*)*.* His study of utterances required transcending the approach of existing disciplines, which he termed 'translinguistics' (Wertsch, 1991, p. 51), which Wertsch claims overlaps with what ‘today is called "pragmatics" or "discourse"…’ (ibid.). Wertsch utilises Bakhtin's concept of utterance to extend beyond Vygotsky’s limitation, which he considers limited due to his linguistic commitments in theorising and analysing speech.

According to Mortimer and Scott, Bakhtin views language as a social affair. He stratifies language into two distinct forms: *social language* and *speech genre*, which offers a useful lens in the analysis of classroom discourse and teaching and learning science. For example, the social language of physicists talking about the structure of glass would be differentiated from discussions on the composition of glass by a glass blower. Speech genre, however, is the *style* of talk entailed in the use of a social language. For example, military communication over walkie-talkie, ‘come in’, ‘over’, ‘copy that’, which attend to the ‘form of utterances’ rather than the *social language*. The vernacular of speech is differentiated from a language's vocabulary range. These two key ideas provide Mortimer and Scott with the theoretical framework that allows them to make the distinction between scientific discourse and science classroom talk. On the one hand, the social language of science identifies the school science discourse, that is, the kind of language and type of vocabulary involved. While on the other hand, speech genre serves to address those aspects of classroom talk that is unique to science classroom talk.

In addition to *social language* and *speech genre,* Bakhtin captures the nature of our use of language by introducing the concepts of *utterance* and *voice*. He understood *utterance* as the fundamental unit of communication, *voiced* by a speaking subject in *social language*, in using words and sentences in their actual context. However, *utterance* can only exist by being produced by a *voice*. For Bakhtin, *voice* cannot be reduced to ‘vocal-auditory signals’ or merely linguistic objects; it is the expression of a point of view through the act of *utterance* (Wertsch, 1991, p. 51). This idea of *voice* as a difference in 'point of view' accounts for differences in the *activity* of *utterance*. An utterance is to be understood as a unit of analysis of discourse. An utterance is not reducible to linguistic words or sentences, nor does it exclude them. An utterance as unit of analysis extends beyond language, words or sentences but involves at least two voices. An utterance essentially captures '*who is doing the speaking* - the fact that "the utterance has …an author" (1986, p. 95) - and a concern *with who is being addressed'* (p. 53). An utterance entails the social and responsive context in which words are used and manifest in speech communication or discourse. For Wertsch, language is dialogic, understood as any discourse involving the utterances of more than one person: the utterance of others. In dialogue, '[a]ny utterance involves at least two voices: the voice producing it and the voice to which it is addressed (Wertsch, 1991)' (Mortimer and Scott, p. 121). According to Wertsch, Bakhtin viewed meaning as 'active process rather than a static entity.' (Wertsch, 1991, p. 52). Wertsch claims Vygotsky lacked an appreciation for such context sensitivity of meaning or the pragmatics of language. As a result, his appeal to Bakhtin, who attends to the social context of language-use, contributes to a shift in research focus from linguistics to pragmatics.

Wertsch suggests that both as Soviet thinkers share the same 'intellectual milieu'[34] (ibid., p. 17). He claims there are sufficient grounds that 'their ideas are quite compatible on several counts, which has allowed me to incorporate aspects of the thinking of both into a theoretical framework that extends beyond either writer's particular set of concerns' (ibid., p. 17). Wertsch relegates the differences and

[34] This is an assumption which is problematic, when viewed in light of Vygotsky's Hegelian heritage and his role as a philosopher concerned with epistemological issues. This philosophical dimension has been neglected by Wertsch, which has consequences for his interpretation of Vygotsky. However, these are issue I raise in passing here and focus on developing in the next chapter on Inferentialism, Vygotsky and Hegel.

similarities between Bakhtin and Vygotsky as secondary, peripheral and as merely related to the Soviet context in which they emerged. This allows him to simply side-step the debate between respective scholars and allows him to pave the way, unhindered, for his ‘post-Vygotskian’ approach that integrates Vygotsky and Bakhtin under a single theoretical framework. Here, I want to underscore that Wertsch’s interpretations follow from his perspective as an American psychologist. The limitations he reads in Vygotsky are fundamental assumptions of his Anglo-American ‘post’-Vygotskian scholarship. However, such assumptions have come under increasing scrutiny within the emerging field of Vygotsky studies, particularly by Derry’s (2013a) philosophical re-examination of his corpus. In the next chapter, I review Wertsch’s assumptions treated as preliminaries for a more in-depth discussion. For the present, I delimit my focus to Mortimer and Scott’s operationalisation of the sociocultural in illuminating the meaning-making problem.

3.2.3 School Science and Science Classroom Discourse

Wertsch considers Vygotsky as a Soviet psychologist confined to issues of development of mind concerned with the semantics of language at the cost of pragmatic considerations. He argues that Vygotsky’s focus on the development of speech (talk) neglects the nature of discursive activities or fails to provide a framework to account for it. In contrast, focusing on the *use* of language and meanings (pragmatics), Bakhtin is viewed as understanding the nature of language as a human activity. Wertsch considers Bakhtin’s pragmatics as extending beyond the confines of Vygotsky’s semantics concerned with abstract thought, rationality and meaning. He views Bakhtin as understanding the use of language as a means of using and making meaning through discursive practices as a social activity. Mortimer and Scott adopt this sociocultural perspective in developing their '*dialogic meaning making'* in investigating science discourse and classroom dialogue (2003, p. 12).

For Mortimer and Scott, it is Vygotsky and his insights that expose the social and cultural origins of concept development, and subsequently makes explicit the distinction between everyday and scientific concepts in learning and developing conceptual understandings. At the same time, Bakhtin provides critical insight into discursive practices. Bakhtin recognises the role *social language*s play in the use of words and sentences within communities. These communities are reflected in the social languages of curricular subjects in schools. Although Mortimer and Scott agree with Vygotsky's theory of development, they follow Wertsch in extending his ideas using Bakhtin to recognise how 'from birth, each one of us is immersed in *everyday social language'* (Mortimer and Scott, 2003, p. 13) which they express as follows:

> In a strong sense, the everyday social language acts to *shape* our view of the surroundings, drawing attention to particular features and representing those features in particular ways. For example, the way in which we routinely talk about the Sun 'rising and setting' helps to develop a strong view of the Sun moving through space, rather than the Earth spinning on its axis. The informal or spontaneous concepts (Vygotsky, 1934) that constitute an everyday social language include many of those views that are referred to as 'alternative conceptions' or even as 'misconceptions' in the science education literature. (Mortimer and Scott, 2003, p. 13)

From a post-Vygotskian perspective, Vygotsky struggled to grasp the context sensitivity of language and the way concepts live within discursive practices or language use. In Mortimer and Scott's view, it is not just Vygotsky's distinction between concepts and differences in meanings that is important, but Bakhtin's acknowledgement of their constitution as part of a *social language*. Although these *social languages* may conflict, they can co-exist within a disciplinary domain and discourse. There is no strict dividing line between everyday and scientific *social languages*. Rather they cross-pollinate and influence each other across various knowledge domains or disciplinary communities. Mortimer and Scott illustrate this point by drawing on science classroom talk which explains scientific concepts using everyday ideas, for example, 'plants feeding from the soil' (Mortimer and Scott, 2003). Feeding for example, in everyday sense involves eating and putting food in our mouth and digestion. The plant does not engage in any of these activities. However, feeding is what we do in order to get energy and nutrition. Our everyday understanding of feeding is used to explain what plants do to grow and survive, 'feeding' from the soil, that is taking nutrition to sustain itself and to deposit or excrete waste into the soil. The significance lies in understanding how scientific language develops 'without conscious awareness through immersion in everyday social language.' (ibid.).

Mortimer and Scott further distinguish between the social language of *science* and the social language of *school science* (2003, p. 17). They consider *real science* as carried out in professional settings, whereas *school science* is enacted in classrooms (ibid., p. 14). The school science ways of talking and thinking are defined and constrained by some national curriculum or school dictates. An example Mortimer and Scott provide of such ways of thinking and talking is how 'solids are typically represented in school science as regular arrays of close-packed particles or atoms.' (ibid.). While they recognise that '*real science*'[35] understands that very few solids display such a structure, it remains the '*canonical representation* of solids within school science' (ibid.). School science and the school curriculum constitute a social language in and of itself. The school curriculum consists of a range of subjects and hence different social languages. According to Wertsch, in gaining competence across a collection of social languages viewed as tools, learners build up a *toolkit* of ways of talking and thinking about the world (Mortimer and Scott, 2003; Wertsch, 1991). From a sociocultural perspective, teaching involves rehearsing ideas of the social language of science and inducting them into the community of school science. From the learner's side, it involves becoming a participant in the social language of science.

Mortimer and Scott place substantial emphasis on Bakhtinian notions of *utterances* and *voice* in understanding the nature of teaching and learning science. However, their account lacks an explication of the role of autonomy and judgments individuals express through using such *voices* and *utterances*. For example, according to Mortimer and Scott, Wertsch considers '[t]his toolkit can be drawn upon by the individual, as appropriate, in different contexts.' (2003, p. 13). Such an analogy leaves the nature of rational judgment and autonomy underpinning the use of tools, such as linguistic expressions, under-theorised. This is an argument that Derry addresses in developing her critical response to post-Vygotskian scholarship. In contrast to Anglo-American scholarship, Derry's philosophical interpretation gives pride of place to the role of our reasoning, judgments, and freedom in accounting for

[35] '*Real science*' is a technical term Mortimer and Scott employ in establishing an important distinction between their understanding of the *social language of science* and the *social language of school science*. *Real science* draws on the language of professional settings, whereas *school science* as enacted in the classroom. (Mortimer and Scott, 2003, p. 14)

human knowing, meaning and meaning-making. The philosophical turn Derry's scholarship initiates serves to illuminate points of tensions within the sociocultural approach and, I argue, offers an alternative response to the meaning-making problem, a discussion I defer to the next chapter.

3.3 Dialogic Teaching and Professional Teacher Development

3.3.1 Dialogic Teacher Development

In observing science classrooms over several years, Mortimer and Scott found that science teaching and classroom interactions were often limited, with the *interactive/authoritative* approach being by far the most common. They suggest a presentational or lecture-style approach is adopted 'simply because it represents the existing, invisible, taken-for-granted practice of science teaching.' (2003, p. 110). Their sociocultural analysis illuminates the 'invisible nature' of classroom talk and teaching practices and promotes more discursive strategies. Subsequently, the resultant approach has been referred to as *dialogic teaching*. While they focus on the *dialogic nature* of meaning-making in classrooms, they do not explicitly refer to their approach as 'dialogic teaching'. Nevertheless, numerous researchers continue to identify their approach as dialogic teaching (Mercer et al., 2009; Lehesvouri, Viiri, and and Rasku-Puttonen, 2011). Many studies with in-service and pre-service teachers have been conducted in primary science (Lehesvuori et al., 2011; McMahon, 2012; Löfgren, Schoultz, Hultman and Björklund, 2013; Viiri and Saari, 2006). Drawing on MMF, Mercer, Dawes and Staarman (2009) report on primary science classrooms using the term 'dialogic teaching'. The primary science dialogue illustrated in Chapter Two forms part of a project by Phil Scott, Jaume Ametller, Neil

Mercer and Lyn Dawes from 2005-2007 entitled ‘Dialogic teaching in science classrooms’.

Reporting research on the professional development of pre-service and in-service science teachers, they claim their analytic framework was found to be extremely helpful. Their framework was employed in professional teacher development programmes by analysing science teaching videos with student teachers on teaching placements. Working in small groups, student teachers examined science lesson recordings, divided into main teaching episodes. Each episode was analysed by students using the aspects of the framework (for example, see Chapter Two). Mortimer and Scott acknowledge how their analytic framework and dialogic approach to science teaching and teacher development ‘calls for quite a fundamental reappraisal of how we conceptualize the planning and implementation of science teaching.’ (2003, p. 109). In advocating the dialogic approach, they attempt to respond to the question of whether ‘such an approach might be more effective than existing practice in supporting student learning?’ (ibid., p. 109). Drawing on their own research and appealing to a ‘small number of studies’ informed by a sociocultural approach that attends to the diversity of classroom dialogue, they claim such an approach indicates it ‘might be associated with enhanced learning outcomes’ (Mortimer and Scott, 2003). Elsewhere (Scott and Mortimer, 2005), they report studies conducted by a group of Finnish researchers (Viiri and Saari, 2006), which later led to collaborative studies (Lehesvuori, Viiri, and Scott, 2009). This collaboration between Finnish researchers and Scott is of particular interest. The former researchers have produced an increasing number of studies dedicated to the implementation and effectiveness of the communicative approach in teacher training and dialogic approaches in primary teaching (Ratinen, Viiri, and Lehesvuori, 2013;

Lehtinen, Lehesvuori, and Viiri, 2019). Furthermore, a number of these studies focus attention on primary science. The collection of studies highlights some of the benefits Mortimer and Scott begin to indicate. However, they also allude to some emerging challenges facing MMF and dialogic approaches in implementation in teacher development and pedagogic practice.

3.3.2 Some Emerging Challenges in Dialogic Research

A team of Finnish teacher educators have been researching communicative and dialogic approaches for nearly two decades. Viiri and colleagues have been accumulating a growing body of research studies focusing on using and implementing MMF in teaching training, with an emphasis on their communicative approaches analysis. Although they are sympathetic to Mortimer and Scott's key message, they recognise that fundamental practical challenges remain. They identify a central need to help teachers understand and learn to empower their teaching practice and student learning through classroom talk. In their study of student teachers, Lehesvouri et al. (2011) claim:

> This project has reinforced our prior assumptions that student teachers have difficulties understanding broader educational theories and their relevance in everyday teaching. Sociocultural aspects of teaching and learning are included in the curriculum but dialogic teaching and its practical applications are rarely highlighted, detailed, and practiced during field practice. (2011, p. 722).

However, in delivering professional teacher development programmes, Lehesvouri et al. (2011) report how student teachers often find it challenging to understand how broad educational theories are relevant in everyday teaching. In attempting to redress this issue, they assert:

> Teachers should be provided with material including exemplary dialogic discussions and some general/specific hints (e.g., possibly emerging misconceptions) for planning and implementing these approaches. Furthermore, teachers should be provided with information about how to deal with emerging understandings in order to engage in educationally-purposeful extended dialogues (a limitation also noted within this study). (p. 723)

Lehesvouri, Viiri and colleagues' point and perspective, in supporting Mortimer and Scott's findings, acknowledge that classroom interaction remains commonly dominated by lecturing or closed questions followed by evaluative feedback (e.g., Mercer et al. 2009; Molinari and Mameli, 2010) typically defined by IRF-patterns (Lemke, 1990; Mortimer and Scott, 2003, Scott, Mortimer and Aguiar, 2006, Sinclair and Coulthard 1975). Furthermore, they are concerned with how 'few studies report on teacher education programs and method courses specifically addressing how teacher-talk can be taught to student teachers and practiced during preservice.' (Lehesvouri et al., 2011). This challenge has led to an increasing number of Finnish-based studies dedicated to redressing the meaning-making challenge (see Chapter Two). They articulate the challenge in their studies of dialogic approaches to teacher development, by spotlighting '…the ways student teachers embrace the content of innovative teaching programs both in theory and practice is also insufficiently addressed.' (Lehesvouri et al., 2011). Their claim that teachers find it difficult to understand the relevance of general educational theory to their practice begins to identify a gap or disconnect between pedagogic theory and classroom practice.

Mercer and colleagues adopt a slightly different approach in reporting on dialogic teaching in primary science (Mercer and Dawes, 2009). While they acknowledge the wealth of research available to teachers on classroom talk and in guiding student learning, they recognise there has been relatively little impact on the *quality* of classroom talk (ibid.). They refer to 'Mortimer and Scott's scheme' as an exemplar of a dialogic approach which recognises no single communicative approach is 'intrinsically superior' while appreciating that 'the implication is rather that the quality of teaching will depend on a teacher's strategic use of interactive and dialogic approaches at different stages of a lesson or series of lessons.' (2009). However, Mercer et al., echo Lehesvouri, Viiri and Rasku-Puttonen's claims about classroom talk in Finnish classes, that despite the research and evidence, classroom talk remains 'commonly dominated by closed questions, short pupil responses and little direct attention being given to the use of talk for teaching-and-learning' (Mercer et al., 2009, p. 355). Addressing issues related to teacher education, classroom talk and dialogic approach, Mercer et al. (2009) state:

> Our own view (supported by other researchers, e.g. Hardman 2008) is that the results of years of research about classroom talk have had relatively little impact on the content of the initial and in-service training of teachers in the United Kingdom. Most teachers do not have a high level of understanding of how talk 'works' as <u>the main tool of their trade</u>, and very few have been taught <u>specific strategies</u> for using it to the best effect (p. 363 [emphasis added]).

So, while Mercer and Dawes present dialogic teaching in a positive light, displaying a 'high degree of consensus amongst researchers about the educational implications', they nevertheless express concerns. This concern is expressed in their review of classroom talk research spanning 40 years, where they claim, had they published 20 years earlier, 'it is likely that much the same conclusion would have been reached about the basic patterns [of participation in classroom talk]'. They recognise a certain consensus, acknowledging 'little has changed', as a sign of reassurance of results replicated in studies. However, Mercer and Dawes quote Howe and Abedin in their conclusion, endorsing their claim that 'given an essentially static situation over 40 years ... arguably the characterization of dialogic patterns should not be accorded high priority when it comes to future research. (Howe and Abedin, 2013, p. 345)'.

This static situation, though not a direct criticism of dialogic approaches, nevertheless calls for a fundamental shift in approach and focus within dialogic research. In their review, Mercer and Dawes indicate that regardless of the pedagogic and research challenges, what seems to be growing in recognition and demand by teachers is a need for quality classroom dialogue. As Mercer and Dawes express:

'In our own experience, as judged by requests for professional development sessions and participants' responses to such sessions, interest amongst teachers in understanding and improving the quality of classroom talk is higher than it has ever been, not only in Britain but internationally.' (2014, p. 441).

In sum, the level of dialogic research with teachers and teacher educators has been on the rise. While much has been learnt about dialogic teaching and teacher awareness and demand on the ground remains high, translating pedagogic theory into classroom practice in dialogic teacher development remains challenging.

3.3.3 Dialogic Teaching Research, Impact and Current Issues

Above I identified some emerging challenges that arise from introducing MMF and the analytic framework within initial teacher education and development. The significance of dialogic teaching in professional practice has been gaining ground (Lehesvuori, Hähkiöniemi, Ketonen, Lerkkanen, Pöysä, and Pakarinen, 2021; Howe and Abedin, 2013; Mercer and Dawes, 2014). However, Lehesvuori and colleagues demonstrate that implementing dialogic pedagogy in content-driven subjects such as science and mathematics remains challenging (Lehesvuori et al., 2011, Lehesvuori et al., 2021; Lehesvuori, Hähkiöniemi, Jokiranta, Nieminen, Hiltunen and Viiri, 2017). While they acknowledge this development of dialogic pedagogy has not been as voluminous[36] in mathematics education (Bakker, Smit, and Wegerif, 2015; Lehesvuori et al., 2021, 2017), it has nevertheless developed in parallel with science education in recent decades (Bakker et al., 2015; Ketonen, Lehesvuori, Pöysä, Pakarinen and Lerkkanen, 2022; Lehesvuori et al., 2017, 2021; Mortimer and Scott, 2003; Scott, Mortimer, and Aguiar, 2006). In addressing both science and mathematics education, these Finnish scholars claim that 'teachers still do not have exact models of how to orchestrate more dialogic interactions, even if they are aware that it will have a positive effect on students' learning (Lehesvuori et al., 2017).' (Lehesvuori et al., 2021, p. 2). While a host of empirical studies have garnered increasing interest in dialogic approaches to teaching, they have also served to explain how dialogic teaching manifests in classroom interactions and educational dialogues (ibid.). However, some researchers claim studies that address how dialogic theory can be meaningfully linked to teacher education and professional development programs at both pre-service and in-service levels remain limited (Lehesvuori et al., 2021, Sedova, 2016, 2021).

[36] Interestingly, the converse applies to the inferentialist approach, which I discuss in the chapter, which has been developed within mathematics education, with Causton and myself being the two who have addressed the matter within science education.

Teachers orchestrating classroom talk in teaching practices are faced with the practical challenge of finding and striking a balance between open and closed questioning (Lehesvuori et al., 2021). This delicate balancing act in moving between opening up and closing down classroom talk (Scott and Ametller, 2007; Lehesvuori and Ametller, 2021; Lehesvuori, Hähkiöniemi, Viiri, Nieminen, Jokiranta and Hiltunen, 2019) manifests as teaching rhythms in their communicative approach to teaching (Nurkka, Viiri, Littleton and Lehesvuori, 2014). Studies with pre-service teachers aimed at establishing dialogic teaching illustrate the continued issue of tension between authoritative and dialogic approaches in classroom talk (Lehesvuori et al., 2021, 2019; Scott et al., 2006). Mortimer and Scott's relation of communicative approaches to teaching purposes and scientific story (2003) in planning and teaching is viewed not only as rationalising the use of dialogic strategies but also makes 'choosing a specific questioning strategy much easier' (Lehesvuori et al., 2021). In thinking about this orchestration of meaningful interactions, Lehesvuori and colleagues suggest 'careful scrutiny of the transition phase from dialogic (opening up) to authoritative (closing down) could provide new information about achieving and maintaining the balance between different forms of interaction' (Lehesvuori et al., 2021; 2019). However, working with pre-service teachers in introducing and developing dialogic principles and approaches, it has become increasingly clear for researchers and educators that they need to acknowledge 'the gap between ideological dialogism and classroom realities' (Lehesvuori et al., 2021). A concern with this gap between dialogic theory and classroom practice has been identified and shared by several researchers (Mercer and Howe, 2012; Lefstein, 2010).

Following over a decade of studies, they are constrained in drawing conclusions about the sustainability of the dialogic approach, 'especially when it comes to the success of future implementations of dialogic approaches.' (Lehesvuori et al., 2021). Furthermore, they remain concerned with how 'teachers would need ongoing support during their early years in teaching in order to prevent them regressing back to more teacher-centred and authoritative approaches (Lewis, 2014).' (ibid*.,* p. 11). While Lehesvuori and colleagues draw attention to research on how dialogic principles could 'enhance meaningful learning', they also highlight 'how this could be practiced systematically in subject teachers' preservice training remain scarce' (Lehesvuori et al., 2021, p. 2).

Mortimer and Scott's meaning-making Framework (MMF) is one among various teacher professional development approaches or programs (TPD) that have been introduced to promote dialogic teaching in schools over the last few decades (e.g., Alexander, 2018; Lefstein and Snell, 2014; Lehesvouri et al. 2011, 2019; Sedova et al., 2016). In her review of dialogic TPD, Klara Sedova claims '[s]ome of these projects reported only limited or no outcomes; others were successful' (2021). However, even amongst the successful projects, researchers report how shifting teaching practice towards dialogic teaching is a challenging endeavour demanding a lot of effort and support (Sedova, 2021; Sedova, Sedlacek, Svaricek, Majcik, Navratilova, Drexlerova, Kychler, and Salamounova, 2019; Snell and Lefstein, 2018). Echoing pre-service teacher studies, their concern is that without additional opportunities and support, teachers may regress or '[n]ewly mastered teaching skills may fade' (Sedova, 2021, p. 39). While Sedova speaks to dialogic teaching as a movement, she is centrally concerned with the sustainability of teacher change, which if temporary, undermines dialogic TPD programmes. In expressing her concern, Sedova states: 'Unfortunately, there is nearly no data about the long-term impact of dialogic teaching TPD initiatives. To my knowledge, few studies have investigated the sustainability of dialogic teaching' (ibid.) Sedova and her colleagues have shown how changes in 'teacher communicative methods through education' are possible. However, the impacts of dialogic teaching on teachers and changing their practices remain an 'underexplored field' (Sedova, 2021, p. 53). While she acknowledges, the dialogic theory has been well developed, the small effect on teaching practice leads her to side with the pre-service researchers above and Mercer and Howe (2012) in stressing the importance of addressing the gap between theory and actual practice in order to legitimise dialogic TPD.

The scarcity of research and impact studies across both pre-service and in-service teachers highlights that work remains in developing a better understanding of how dialogic theory links to practice in ways that ultimately bridge the gap between dialogic theory and classroom interactions (Sedova, 2021, 2020; Lefstein, 2010; Mercer and Howe, 2012; Lefstein and Snell, 2014).

3.3.4 Critical Overview and the Role of Inferentialism

Recognising the tension between two historically distinct strands of research – psychological studies of student learning and sociological concerns with classroom environments, Mortimer and Scott's research framework sought to integrate and subsequently relieve such tensions. The subsequent communicative analysis of classroom discourse (authoritative and dialogic discourse) inspired their conceptualisation of meaning-making and dialogic teacher development. In presenting a historical developmental narrative of their framework, I have highlighted some of the tensions and challenges or a theory-practice gap that has begun to emerge in classroom research and professional teacher development.

The central claim that animates the present thesis is that if we wish to move the field of dialogic research forward, we may need to step back to re-examine the theoretical and methodological underpinnings involved in investigating classroom talk and meaning-making. I contend that such a move is offered by Jan Derry in her philosophical re-assessment of Vygotsky and meaning-making. Her alternative scholarship offers a fresh theoretical perspective in reassessing long-standing issues and tensions. Furthermore, the challenges that manifest in dialogic pedagogic can be traced back to MMF's research methodology and sociocultural theory rooted in Wertsch's Anglo-American interpretation of Vygotsky.

As I explore the implications of Derry's Vygotsky scholarship, I do not dismiss Mortimer and Scott's years of classroom research or dialogic approach out of hand. Rather than set up a false dichotomy, I suggest a different philosophical orientation offers an alternative approach to explaining why these tensions and explanatory gaps manifest in the first place. A better understanding of the problem illuminates new possibilities and alternative avenues of research in moving forward. Derry's reading of Vygotsky's thoughts on knowledge, mind and meaning involves appreciating his philosophical orientation, which she relates to contemporary developments in analytic philosophy advanced by Robert Brandom and his philosophy of language: *inferentialism*, which I discuss in the next chapter. The present study in exploring neglected dimensions in Vygotsky's work, offers a critique of MMF through a systematic deconstruction and re-conceptualisation of meaning-making. Although such philosophical issues may seem far removed from practical matters of science teaching, I consider their implications for dialogic meaning-making and analysing science classroom talk. The remaining chapters focus on illustrating and illuminating powerful insights gained into how we think, talk and act in science classrooms.

4 Vygotsky Mind and Meaning: A Philosophical (Re-)Orientation

In the preceding chapters, I discussed Mortimer and Scott's analytic framework and their dialogic approach to science teaching. In the present chapter, I focus on *inferentialism*, a philosophy of language and theory of meaning and communication, that directly impacts my central concern with meaning-making in classrooms. I examine how this contemporary account of semantics and epistemology, rooted in the Hegelian tradition, takes the nature of our mind and rational judgments as fundamental in an explanatory account of our knowledge and meaning. This approach sits in opposition to traditional semantics and epistemology that take the relation between the world and mind or word and referent as fundamental to their explanatory strategy. This Hegelian tradition has significance for reading Vygotsky and subsequently theorising and re-conceptualising meaningful communication and learning in science classrooms. I review the challenges presented in the previous chapters, viewed here, through a philosophical lens. The subsequent conceptual re-orientation offers a theoretical framework that animates the present thesis. The remaining chapters systematically develop the inferential orientation initiated here along theoretical, methodological, and pedagogical lines in considering its implications for meaning-making in primary science classrooms.

4.1 Vygotsky Scholarship and Inferentialism

4.1.1 A Philosophical Turn in Vygotsky Scholarship

In recent years, closer attention to Vygotsky's entire corpus has given rise to the field of Vygotsky Studies (Roth and Jornet, 2017; Yasnitsky and Van der Veer, 2015).

Such research extends beyond translational issues (Cole, 2009; Rieber and Carton, 1987) to address the historical and cultural context in which his collective work was generated. Subsequently, increasing emphasis has been placed on exposing the limitations and shortcomings of Anglo-American interpretations, which have become fashionable, mainstream and even popular characterisations (e.g., Godfrey-Smith, 2016; Nisbett, 2005; Tomasello, 2009).

Of central interest here is Jan Derry and her influence on Vygotsky scholarship. Although she aligns with the sentiments of Vygotsky Studies, her re-assessment of Vygotsky's work shifts the focus from linguistic, historical and cultural issues related to Soviet thought to alert scholars to the philosophical tradition in which he worked (Derry, 2013a). In the hands of Anglo-American scholars, she argues, 'the nature of the philosophical underpinnings of Vygotsky's work tends to receive little attention.' (Derry, 2013a, p. 1). Her argument is not that historical or philosophical references have been merely overlooked, but rather, in the absence of a fuller appreciation of the nature of Soviet thought and tradition, Anglo-American scholars have failed to recognise Vygotsky as an epistemologist concerned with philosophical issues and perspectives (Derry, 2013a; Dafermos, 2018a). She spotlights how Vygotsky explicitly stated his debt to philosophers Hegel and Spinoza and that they remain implicit throughout his works. Subsequently, her scholarly work alerts us to the depth and richness of Vygotsky's long-neglected Hegelian heritage. The upshot of ignoring such critical philosophical elements in Vygotsky's thinking about language, mind and meaning, according to Derry, is the losses incurred from readings that 'subtract from its contemporary relevance and diminish the contribution it can make to current educational questions' (Derry, 2013a, p. 31). Her re-interpretation of Vygotsky (Derry, 2008, 2013a, 2016) attending to his Hegelian heritage is particularly pertinent here, as she defends him against Wertsch's criticism that charges him with being an ambivalent Enlightenment rationalist (see Chapter Three). She argues that Vygotsky exercised a 'far more sophisticated conception of reason and meaning than Wertsch appreciates' (Derry, 2013*a,* p. 1), and her critical response extends beyond Wertsch to bear on other post-Vygotskian thought and theories (e.g., Mortimer and Scott, 2003).

Derry is not alone in alerting us to the philosophical dimensions of Vygotsky's thought (Bakhurst, 2011; Blunden, 2012; Dafermos, 2018; Roth, 2017). However, her restorative approach to Vygotsky scholarship has garnered increasing attention and led to an emerging body of research in education (Bakker and Derry, 2011; Causton, 2019; McCrory, 2015, 2017; Firth, 2017). Manolis Dafermos (2018a), himself a Vygotsky scholar, offers a ringing endorsement of Derry's restorative scholarship in his book entitled *Rethinking Cultural-History Theory: A Dialectical Perspective to Vygotsky*, where he declares:

> From my perspective, Jan Derry's book "Vygotsky Philosophy and Education" is the most important contribution to the investigation of the philosophical underpinnings of Vygotsky's theory. Derry demonstrates that "...Vygotsky was influenced by a different tradition of philosophy from that which has influenced post-Vygotskian research" (Derry 2013, p. 4). …Moreover, Derry reveals the essential differences between Vygotsky's theory and constructivism that has emerged as a powerful discourse in the contemporary post-Vygotskian Academia, especially in the field of education. (2018a, p. 67)

In undertaking a philosophical re-examination of Vygotsky, Derry not only considers a historical Hegel but also draws critical links with contemporary Neo-Hegelian philosophers, John McDowell and Robert Brandom. Thus, she brings Vygotsky's neglected insights into fuller significance, which are current in philosophy and relevant to education.

4.1.2 Vygotsky and the Pittsburgh School of Philosophy

According to Wertsch's Anglo-American interpretation, Vygotsky's work was generated under the influence of the 'Enlightenment project' (see Chapter Three). In brief, this idea considers our grasp of concepts and meaning as deriving from our abstract and internal reasoning faculties or *abstract rationality*. Wertsch views Vygotsky as coming to realise the problems of Cartesian epistemology only 'late in life' (Wertsch, 2000). However, in alerting us to Vygotsky's neglected Hegelian heritage, Derry rejects Wertsch's reading as ascribing to him an epistemology that was not his own. She clarifies that '[c]entral to Wertsch's argument that Vygotsky was an ambivalent rationalist is the claim that Vygotsky operates with 'an assumption that language and meaning are basically concerned with referential relationships between signs and objects' (Wertsch, 2000, p. 20).' (Derry, 2008, p. 54). Her philosophical reading acknowledges the neglected German Idealist tradition that influenced Vygotsky's work (Derry, 2013a, p. 31) and articulated in Derry's critical proclamation that 'Vygotsky never entertained an idea of abstract reason' (ibid.). Derry's perspective situates her scholarship in opposition to the mainstream and fashionable post-Vygotskian commentaries. Developing her line of criticism, she exposes implicit epistemological commitments that underpin Wertsch's scholarship (and, by implication Mortimer and Scott's framework). By demonstrating how Wertsch appeals to the concept of *mediational means* in explaining knowledge and concept-meaning, she shows he relies on a form of causal relation (i.e., 'means').

This causal relation she argues ultimately falls back on a mind-world relation and thus retains dualism. In short, his explanation inadvertently retains a relation which is itself left unexplained. The idea that Wertsch retains a mind-world dualism may seem to run counter to a close reading of his work. Since this was a charge Wertsch himself levelled against Vygotsky, on account of his allegiance to Cartesian epistemology. In making explicit Wertsch's implicit commitment to a relational dualism, Derry claims that his position, in fact, sits at odds with Vygotsky's own commitments as rooted in the Hegelian tradition. The Hegelian philosophical tradition, as Derry explains, adopts a non-dual approach to explaining knowledge and meaning. While I discuss what such a non-dual approach involves in more detail below, it is critical to acknowledge that a significant reason for disregarding these philosophical dimensions lies in the Anglo-American reception, interpretation and appropriation of Soviet thought. Many scholars still view Vygotsky through the lens of linguistics and psychology, as opposed to a Soviet thinker and Russian philosopher with a non-dual epistemological orientation, concerned with issues of sociogenesis of human minds, meaning and knowing.

Another important reason that has further complicated an understanding of Vygotsky concerns the philosophers that inspired and influenced his work, namely, Hegel and Spinoza. Derry articulates this issue, claiming:

> One reason for the neglect of this area by non-philosophers is the difficulty of grasping the relevant material. The philosophers to whom Vygotsky owes a special debt (Hegel and Spinoza) are notoriously difficult to understand; in the case of Hegel the difficulties are compounded by serious misrepresentation (Pinkard 2000). (Derry, 2008, p. 56).

Such misrepresentations of Hegel have been a central focus for philosophers belonging to what has been dubbed the 'Pittsburgh School of Philosophy' (Maher, 2012; Rockmore, 2012; Sachs, 2019). The term 'Pittsburgh School of Philosophy' is relatively recent although it has been gaining traction within the field of philosophy. I am drawn to the term as it attends to a group of philosophers who, for all intent and purposes, share much in common about the nature of knowledge, mind and the world. This shared perspective sets them apart from other philosophers or schools of thought. Maher (2012) coins the term 'Pittsburgh School of Philosophy' in his book of the same title[37]. However, he is mindful to acknowledge that in employing the term, he does not intend to explicitly defend it. The main reason for calling a group a school is that despite differences, they share many concerns and views. The term more obviously addresses the fact that they have all taught in the Department of Philosophy at the University of Pittsburgh. Brandom's mentor Wilfred Sellars taught there for over twenty-five years until his passing in 1989. Richard Bernstein (2010), in narrating historical developments in American Philosophy[38], acknowledges how the prominent writings of John McDowell and Robert Brandom have served to garner a greater appreciation of the works of Sellars, and they both continue to teach there today. Together, they are known as the 'Pittsburgh Hegelians' (Bernstein, 2010; Derry, 2013a). In taking stock of these contemporary developments in philosophy, Derry refers specifically to the neo-Hegelian work of Sellars, Brandom and McDowell. Inspired by the work of Wilfred Sellars[39] they have both invested

[37] Maher's book title in full reads 'The Pittsburgh School of Philosophy: Sellars, McDowell, Brandom (2012).
[38] Bernstein's book entitled 'The pragmatic turn' (2010), provides a historical narrative of the development of pragmatism both in American and its global influence culminating in the works of the Pittsburgh philosophers.
[39] Sellars, in taking issue with empiricism, wrote extensively on the philosophy of science, which has a relevance that runs deep in relation to the language of science and the meaning of scientific concepts relevant to the present discussion. Although such discussions may be interesting, fruitful and illuminating in highlighting important connections that play into the current debates, due to limitations of space, I limit my discussion to focus largely on Brandom and following Derry's reading of Vygotsky. The fact that such movements are

significant efforts in reviving Hegel, but what makes them ‘neo-Hegelian’ thinkers is their active attempt to ‘domesticate Hegel’, that is, to bring Hegel back into the fold of analytical thought (Bernstein, 2010). Their philosophical thoughts are particularly relevant here in bringing Vygotsky to bear on current philosophical issues (Bakhurst, 2011; Derry, 2013a; Webb, 2023).

As a whole, the Pittsburgh School presents a complex terrain and difficult vocabulary to engage with (Maher, 2012), and the chapters below aim to tackle this particular challenge. Nevertheless, Brandom is acknowledged as one of the most influential philosophers of our time (Loeffler, 2018; Wanderer, 2008; Weiss and Wanderer, 2010), although the uptake of his work has been slower than his contemporary John McDowell. As Weiss and Wanderer explain, the reason is that Brandom’s work is much longer, technical and complex, offering a full-blooded theory in a more systematic fashion, which tends to have fallen out of fashion in contemporary approaches in philosophy and educational research. In relation to the present thesis, this is not a trivial point, as Mortimer and Scott’s meaning-making framework sought to integrate disparate and conflicting views, which was advanced on the grounds of denying such ‘grand theory’ approaches (Scott, Asoko, Leach, 2008). Brandom, however, explicitly acknowledges his philosophical work as a continuation in the lineage of Hegelian thought and a systematic philosophy (2019). As I focus on Brandom, I take my lead from Derry in alerting us to his neo-Hegelian contribution to the philosophical issues of language, meaning and dialogue, which has direct implications for reading Vygotsky and understanding his original thinking on knowledge, meaning and meaning-making.

occurring and being discussed within the philosophy of science and the scientific community more broadly may be an indication that the trends I develop in this thesis form part of larger global debate (see Chapter Eleven and Appendix 1).

4.1.3 The Pittsburgh Dilemma and Myth of the Given

The study of the mind and knowledge, that is, the fields of Psychology and Epistemology, are caught between two seemingly irreconcilable aspects of knowing; or as Derry aptly articulates the problem, our ‘experience is understood as something that cannot be a tribunal and yet must also somehow stand in judgement over our thinking.’ (Derry, 2013*a, *p. 32). In Pittsburgh School terms, there is an *epistemological dilemma*, which Derry (2018) acknowledges in her inaugural professorial lecture entitled ‘*Knowledge in Education: Why philosophy matters*’. She asserts, speaking to ideas about education, that there is ‘intense disagreement in education circles, between those who favour facts and disciplines, on the one side, and those whose main concern is 'meaning-making' and epistemic access, on the other.’ (p. 1). She highlights two different views of knowledge. On one view knowledge is considered as *given* by the world or 'objectivity', and on the other it is relative to the *meaning-making* of individuals. With the first view, the central idea here is that knowledge is *Given*, and the problem presented by the Given is roughly that one cannot know anything prior to, or independently of, knowing something else (Maher, 2012). For example, touching a rock does not by itself suffice for knowing it is a rock or what a rock is. To claim otherwise would constitute a form of the Given. The central problem of the Given is the fundamental assumption that we can have knowledge by *immediate* awareness or contact with the world without concepts coming into play (Derry, 2017). This is the idea that knowledge is a result or caused by the world impinging on our senses and ‘interpreted by human construction’ (ibid.*,* p. 407). According to this view, concepts are later developments that emerge from our experience of the world.

The problem of the Given was popularised by the American Pragmatist Wilfred Sellars (1997) in his critique of empiricism succinctly encapsulated by Sellars's phrase 'the Myth of the Given' (Brandom, 2015; Sellars, 1997). As one of Brandom's mentors and heroes, he takes his lead from Sellars. For Derry, Sellars's critique of 'the entire framework of givenness' is a key focus. She draws inspiration from the Pittsburgh School to bring this myth to bear on education, claiming that this 'common and unexamined assumption of a bare Given upon which we make constructions pervades much pedagogic practice' (Derry, 2017, p. 407). Brandom claims Sellars's critique is 'widely appreciated' as having its origins in Hegel's *Sense Certainty* chapter (2019, p. 21).

In tracing this issue to Hegel's concern with immediacy (Sellars, 1997, p. 14), Derry highlights how this central issue underpins Vygotsky's preoccupation with mediation in conceptualising knowledge, mind and learning. For Vygotsky, knowledge is not *immediate* but *mediated* through a developmental process involving human awareness or consciousness. Furthermore, Brandom claims Sellars, in acknowledging this connection, speaks of Hegel as 'that great foe of immediacy' (2019, p. 21). For both Hegel and Sellars, the central argument here is a rejection of the 'intelligibility of any concept of a kind of knowledge that is purely immediate, that involves no appeal to inferential abilities or consequential relations they acknowledge (Hegel's "mediation")'. (Brandom, 2019, p. 22). In sum, any knowledge or concept must involve rational judgment, reasoning and meaning or conceptual content. Without such conceptual content, there can be no knowledge and as such, 'determinate conceptual content must be 'thoroughly mediated' (ibid., p. 21). In other words, one does not receive knowledge immediately from the world, nor can knowledge be *given* through the senses; it is a myth. The fundamental problem of the Given, or any form of representation in explaining knowledge, is that once it is set up as a world-given and mind-received relation, the model invokes a dualism between mind and world, which requires being brought together by some primitive relationship. Thus, the subsequent problem of dualism is endemic to conventional epistemology. Brandom refers to such explanatory accounts of knowledge as representationalist, which he views as, not only a paradigm but as problematic.

According to Derry, this *representational paradigm* refers to a particular epistemological position that assumes ‘the relation of mind to world as one in which knowledge caused by sense experience is made meaningful by the constructions that are put upon it.’ (Derry, 2013a*,* p. 32). This view corresponds to the epistemological position in educational research referred to as constructivism, which Derry identifies in Wertsch and, by implication, underpins Mortimer and Scott’s meaning-making framework, which I address in the next section (see §4.2 below). Put differently, *representationalism* considers the nature of knowledge as *given* by the empirical world received through sense experience (epistemic view), and the mind takes the role of creating meaning out of whatever ‘reality’ has been given from out there, which remains unknowable (semantic view) (Bernstein, 2010; Derry, 2013a). So, what makes this representational paradigm so problematic?

The Regress/Void Dilemma

The central epistemological problem that arises once one recognises Sellars’s critique of the Myth of the Given is how does one go about justifying knowledge? The critical concern that many philosophical views contend with is the *regress problem*. Derry illustrates this problem by citing a tale Vygotsky employed that shows how a single generalisation is not knowledge. Vygotsky, while working with children with special needs, takes issue with a ‘pedagogue of the blind who attempts to replace vision with 'visual images' through other senses (e.g., touch) without understanding the nature of perception.’ (Derry, 2013a, p. 119):

> The blind man asks a series of questions which lead to an *infinite regress* “What is milk like?” – “It is white.” – “What is white?” – “Like a goose.” – “And what is a goose like?” – “It is like my elbow.” The blind man felt the guide’s elbow and said, “Now I know what milk is like!” (Vygotsky, 1993, p. 203 cited in Derry, 2013a, p. 119 *italics added*).

When an infinite regress arises, the problem in giving an explanation is that if it does not stop somewhere, how do I know anything? How am I justified in my thinking of what milk is like? Thus, there emerges a need for some *foundation* of knowledge or justification that would bring the regress to an end. A need for something that can serve as a justification without further reasons or knowledge. For the Pittsburgh School, there is no such thing; there is no Given; it is a myth. So, how do they square that circle?

Brandom’s Pittsburgh colleague, John McDowell, contributes to emboldening the critique from regress by acknowledging that once the Given is rejected on the grounds of regress, a natural corollary is a rejection of foundationalism (Noorloos, Taylor, Bakker, Derry, 2014; Derry, 2013a). This may be too extreme as once foundations are dismissed, it permits a wholesale rejection of any relationship between mind and word, and this is especially problematic when ‘it is thought that a form of foundationalism is the only way to make internal representations square up with the world.’ (Noorloos et al., 2014, p. 322). In McDowell’s terms, the issue lies in becoming a *coherentist* and ‘rejecting any form of constraint on one’s thinking by external reality’ (ibid.). Such an approach risks being like a ‘frictionless spinning in a void’ (McDowell, 1996, p. 11). Put differently, McDowell raises the concern that if we are left with a picture that leads to our reason as free-floating, we risk ‘losing all contact with the world and hence frictionlessly spinning in the void’ (Peregrin, 2014, p. 37). Jaroslav Peregrin, a prominent commentator on Brandom and other Pittsburgh philosophers, clarifies McDowell’s position, by claiming he acknowledges it is not possible to ‘naturalize reason’, which would drag our ‘pieces of knowledge’ into the causal realm, that is, causal explanations that neglects our reason and freedom. McDowell (1996) adopts the only other option, which ‘is to 'de-naturalize' our grasp on the world– to accept that the world is, after all, able to deliver us knowledge that is conceptual: 'The conceptual sphere', [which] McDowell (ibid., p. 72) claims, 'does not exclude the world we experience.'’ (Peregrin, 2014, p. 37).

Derry relates this line of thinking to Vygotsky’s argument, and his response to the pedagogue working with blind children, that acknowledges that ‘perception and representation are not the sphere of compensation for the effects of blindness: 'compensation occurs not in the realm of elementary functions but in the sphere of concepts'’ (Vygotsky, 1993, p. 203 cited in Derry, 2013a, p. 119). In other words, an explanatory account of knowledge, meaning and understanding is not located in our perceptual system or internal representations. For both the Pittsburgh School of Philosophy and Vygotsky, the fundamental move lies in privileging the role of the *conceptual* in an explanatory account of knowledge, meaning and understanding. Such an approach to explanation appeals to our rational autonomy and judgments in interacting within the world as already always conceptual in nature.

Brandom recognises how an explanatory tension lies at the heart of representational accounts of empirical knowledge and human experience of the world on account of the Myth of the Given. This concern with dualism sits at the heart of the Pittsburgh School, following on from Sellars and Hegel before him.

According to Maher, what unites the Pittsburgh School of Philosophy is recognising this epistemological dilemma between traditional empiricism or any form of objectivity (i.e., Myth of the Given). This neo-Hegelian response is underwritten by a non-dualism (i.e., non-representational epistemology). This epistemological non-dualism of a Hegelian order sets them apart from more classical and traditional epistemology, which Brandom refers to as the representationalist paradigm. I contend this dilemma or tensions plagued Mortimer and Scott throughout the historical developments of their meaning-making framework[40] and '*dialogic meaning making'* (see Chapter Three and Chapter Eight).

I appreciate that these epistemological issues are long-standing debates and remain unresolved. I, therefore, confine my discussion here by limiting my attention to introducing Brandom and his position on such matters. Both Sellars and Brandom acknowledge these tensions and understand that this dilemma manifests from a certain dualism between the mind and the world. Brandom continues Sellars's critique in his thinking about rationality (reasoning), epistemology (knowing) and semantics (meaning). As Brandom understands the problem, any epistemological or semantic approach that takes as its explanatory strategy representation, will be plagued by infinite regress on account of dualism. In other words, the resultant relation requires explaining without appealing to another relation that leads to the regress problem while avoiding falling prey to the *Myth of the Given*. Derry identifies this problematic dualism as underpinning representational explanations. She goes

[40] Mortimer and Scott are well aware of this problem. In later developments, they collaborate with philosopher, El -Hani (El-Hani and Mortimer, 2007; Mortimer, Scott and El-Hani, 2011, Mortimer and El-Hani, 2014) and draw inspiration from American Pragmatists (see Chapter Eleven for a brief discussion). However, due to the limitation of space, the discussion of their ad hoc philosophical or epistemological manoeuvres, which I view as failing to do justice in responding to the problem of the representational paradigm, is a discussion I will develop in future publications.

on to state that sitting ‘at the heart of the representational paradigm of the world as independent of mind and made meaningful by the constructions placed on it by mind.’ (2013a*.,* p. 32). In short, falling within a representational paradigm constitutes either appealing to a relation of the mind to the world as a causal relation and as self-explanatory or as a problem of infinite regress. Brandom’s philosophical project attempts to redress this explanatory gap (dualism) and problem (regress) by making explicit how the very nature of such relations arises for us humans who exercise reason and freedom in *coming to know.* Brandom’s philosophical project, inferentialism, aims to expose this fundamental problem of knowledge, meaning and understanding identified and expounded by Sellars and to make his explanatory approach explicit.

While the Pittsburgh School of Philosophy has gained increasing influence in the domain of philosophy, it remains very much in its infancy within the field of education. Despite this, several fruitful developments have inspired my work, which I discuss as I continue to develop in the remaining chapters. The present thesis is an attempt to dissolve as opposed to resolving the tensions that continue to plague classroom talk and meaning-making research.

4.1.4 Vygotsky, Brandom and Inferentialism

Robert Brandom explicitly acknowledges his philosophical work as a continuation of Hegelian thought and his lineage (Brandom, 2000; 2009; 2011; 2019). While Derry acknowledges Vygotsky’s Hegelian roots in theorising thought and talk, she brings into sharp focus the significance of Brandom’s neo-Hegelian philosophy of inferentialism. I take my lead from Derry in focusing on Brandom and his philosophy of language – inferentialism. Her work highlights how his neo-Hegelian contribution to the philosophical issues of language, meaning and dialogue has direct implications for reading Vygotsky. Attending to Vygotsky's Hegelian roots through an inferential lens, Derry offers a unique re-interpretation of the *nature of human thought and talk* in *knowing* and *understanding* and theorising knowledge, meaning and meaning-making (Derry, 2007; 2013a; 2013b).

Brandom's philosophical project, inferentialism, is a rational inquiry into human minds and knowing. He takes as his starting point a consideration of what distinguishes *us, humans,* from non-human animals. According to Brandom, any rational inquiry into human affairs requires recognising the distinctiveness of our human awareness, our *sapience*, as opposed to mere *sentience*. He views the difference between animals and us, between sentient beings and sapient awareness, not as a continuum but as a 'bright line' (Frápolli and Wischen, 2019). This recognition applies whether the field of inquiry be philosophy, psychology, or education and is of immediate significance to the present inquiry. For Brandom, making this sentient-sapience distinction explicit, that is, between being merely *awake* as opposed to being *aware* (Brandom, 2001), involves understanding the crucial distinction between *causes* and *reasons*. As Derry clarifies, the term 'causes', as employed by Brandom, refers to 'a relationship in which no conscious purpose on the part of the agent is involved.' (Derry, 2013a, p. 36). Various examples from nature can explain this (causal) view, relating to sentient beings acting in the world and with other beings, which causes a result without conceptualisation. For example, a bird building a nest, a kettle causing water to boil, an alarm alerting us to a fire, or a smartphone responding to the call 'Hey, Siri!'. Take, for example, a fire alarm, which may be much more 'effective in *perceiving* the dangers of fire and sounding the alert than any human being.' (Derry, 2013a, p. 2 *italics* in original). Consider a young child who, perceiving fire, shouts 'Fire!'. In the latter case, Brandom claims much more is at stake than the mechanical production of noise, as in the case of the fire alarm. For Brandom, the exclamation immediately entails certain consequences related to the child's cry. On hearing the cry 'fire!', others may understand what follows from such an utterance as: 'we're in danger', 'get out quickly' or 'run for your lives!' and so on.

To further clarify this point, take the example of world-renowned chess Grandmaster Kasparov, who was beaten by a computer in a game of chess. Although the computer may have 'won' based on the capability of the software, Brandom's point is that the computer as a set of programs was not rationally engaged in, nor responsive to, *playing* a game of chess, in the manner Kasparov was. It is not engaged in making *judgments*, *aware* of and *responding* to another player's moves. The computer lacks a certain autonomy, awareness and responsiveness, with which we humans engage in thinking and making moves in playing a game. We are involved in making *rational judgments* and assessments and respond *with* and *for* reasons in making moves in response to those made by our opponents. Our capacity to engage in playing a game illustrates Brandom's distinction between *causes* and *reasons*. As humans, when we respond or act or communicate, we do so *inferentially*; that is, we *respond* to situations and people with a distinctive capacity for *reasoning* and awareness of others as acting and communicating with and for *reasons*. Put simply, we act with and for *reasons*, not just causes, such as a fire alarm or a digital chess player. Brandom is not to be misconstrued as dismissing the role of causal relations in human knowing and doing but instead emphasises our being responsive to and for *reasons* in thought, talk and actions. What humans do in reasoning, that is in believing, saying or doing is not comparable nor a mere extension of what non-concept-using creatures do. What we humans *do* is uniquely and distinctively different from non-rational creatures (Brandom, 2001) and subsequently involves an epistemology that takes our rational judgments, autonomy and rationality as fundamental to an explanatory account of knowledge, mind and meaning.

Brandom's *inferential* account of mind takes as its point of departure what is distinctive to us human beings, as knowers and agents in expressing rational judgments in our social and discursive practices. Brandom coined the term *inferentialism*, which characterises his philosophy of language that recognises and privileges the role of reasons and our autonomy in making or expressing our claims. He understands language and our social and discursive practices as playing a game – a *game of giving and asking for reasons*. Brandom acknowledges, as did Vygotsky, the distinctiveness of our human, social, and rational practices. Derry's acknowledgement that Vygotsky was profoundly influenced by Hegel, allows her to draw inspiration from Brandom's neo-Hegelian philosophy of language and rationality i.e., *inferentialism*. According to Derry, it offers rich theoretical resources in reorienting Vygotsky's theory of concept development and learning, which provides an alternative perspective to post-Vygotskian conceptualisations of thought and talk. In order to better under Brandom's philosophy of inferentialism, I return to discuss sociocultural theory in view of Derry's re-assessment of Vygotsky as operating from within the Hegelian tradition.

4.2 Sociocultural Theory Revisited: An Inferentialist Challenge

Derry's Hegelian re-orientation of Vygotsky is deeply influenced by Brandom's philosophy of inferentialism, owing to his fundamental concern with the social nature of knowledge, mind and understanding. Brandom focuses specifically on language and our discursive practices as a distinctively human activity of communication and meaning and is essentially tied up with his account of human knowing, reasoning or rationality. Derry draws inspiration from critical inferentialist arguments in developing her critique of Wertsch's sociocultural theory of development of mind and meaning. To clarify her Hegelian line of argument, I revisit Wertsch's reading of Vygotsky as an Enlightenment rationalist and his semiotic approach to extending Vygotsky's theory of development.

In the previous chapter, we discussed how Wertsch agrees with Vygotsky regarding the sociogenesis of mind and meaning. Wertsch views Vygotsky as understanding concept development and learning as 'mediated' by verbal means (1991, p. 30) and social, cultural and historical processes (Mortimer and Scott, p. 121). In appreciation of Vygotsky's contribution, he states:

> In contrast to many contemporary analyses of language, which focus on the structure of sign systems independent of any mediating role they might play, Vygotsky approached language and other sign systems in terms of how they are a part of and *mediate* human action (thus his association with the term *mediated action).* (1991, p. 29)

However, Wertsch sees Vygotsky as failing to explain how such processes mediate concept development. He criticises Vygotsky's limited capacity to theorise or comprehend linguistic meaning or semiotic activity, as a consequence of his understanding of meanings and claiming he was committed to the view of meaning as 'fixed and unchanging point that remains stable' in language (1991, p. 42**)**. This reading of Vygotsky's view of meaning and mind, as operating in relation to the world and words with a corresponding referent, is read by Wertsch as his Enlightenment view of 'abstract rationality'. Wertsch expresses this view as follows:

> Although he claimed that this distinction is played out in many ways, he examined it only in terms of the abstraction and "decontextualization" (Wertsch, 1985c) of the semiotic means that mediate communication and thinking. (1991, p. 22)

He reads Vygotsky's semantics and semiotic approach as limited. It is to rehabilitate his 'failure to deal with broader sociocultural issues' (ibid.*,* p. 46) and to extend the incomplete project that he draws inspiration from Bakhtin's focus on pragmatics and our use of language that attends to social, practical or communicative contexts, claiming:

> Instead, there is a particular form of semiotic action, a "discourse mode" or a "speech genre," in which linguistic units are understood as abstracted from individual communicative contexts. In this connection it is appropriate to speak of "decontextualized mediational means" (Wertsch, 1985c). (Wertsch, 1991*,* p. 39)

For him, Bakhtin explains 'semiotic action' as a 'mediational means' through discourse modes, linguistic pragmatics, and communicative contexts. According to Derry, Wertsch reads into Vygotsky a commitment to Cartesian epistemology, where the inner mind relates to an external world, operating independently, or as abstract rationality. The problem in theorising mind and meaning in language is explaining the correspondence relation between word and world or reference and referent. Wertsch considers Vygotsky as having struggled to reconcile this tension between the context-sensitivity of meaning with the referential stability of linguistic expressions. Wertsch saw the ‘mediational means’ offered by Bakhtin’s pragmatic approach as bypassing the correspondence problem of reference-referent relation that plagued and confused Vygotsky throughout his life – his ambivalence. Wertsch’s post-Vygotskian theorisation of mediational means is animated by utilising Bakhtinian pragmatics to buttress what he considers as Vygotsky’s defective rationality (mind) and semantics (meaning) limited to a linguistic approach:

> Vygotsky's approach to mental functioning was intended to address issues of sociocultural situatedness; however, he did not deal in any concrete way with many of the major topics implied by a complete approach of this kind. In some cases also, his ideas need to be amended in order to reach the goals he seemed to have in mind (Wertsch, 1985c). (Wertsch, 1991, p. 19)

In sum, Wertsch views Vygotsky as a Soviet psychologist who suffered theoretical limitations. On this view, it was only with Wertsch’s Anglo-American emendation that the project Vygotsky had in mind could bear fruit. His sociocultural theory is considered as correcting and completing Vygotsky’s project, achieved by appealing to Bakhtinian thought that attends to ‘discourse modes’ or social languages, speech genres and utterances, that is, the pragmatics of language use, as opposed to merely limited to linguistics and referential meaning, in short semantics.

According to Wertsch, Vygotsky holds ‘abstract rationality as the pinnacle of thought’ (Derry, 2013a), which colours his understanding of Vygotsky’s conception of mediation. Ascribing to Vygotsky an Enlightenment rationality, Wertsch interprets the concept of mediation as tied up with abstract rationality. Contrary to this reading, Derry argues that Vygotsky was concerned with the distinctive *inferential* rationality recognised by Hegel and Brandom. In her scholarly criticism of Wertsch's account of the sociogenesis of mind and meaning, Derry pays careful attention to illustrating the Hegelian rationality underpinning Vygotsky's work (2008; 2013a). Consequently, she shows how Wertsch's fundamental assumptions instigating a 'post' Vygotskian approach are misplaced. However, her critique of Anglo-American scholarship involves engaging with deeper philosophical issues. In exposing epistemological problems implicit in Wertsch's sociocultural psychology, she challenges his 'sociocultural approach to mediated action' (Wertsch, 1991)[41]Derry takes as a critical target, Wertsch's *post-Vygotskian* interpretation of mediation in terms of 'mediational means'. She argues that the introduction of the idea of 'means' reframes *mediation* as located in 'external objects with causal efficacy' (Derry, 2013a, p. 36). It immediately separates it from our agency and rational judgments in human affairs. Put differently, the <u>world</u> or, in Wertsch's case, here, 'social language' plays a <u>causal role</u> in mediating <u>meaning</u> for individuals. He displaces what he takes as Vygotsky's ambivalent Cartesian correspondence or reference relation and substitutes 'mediational means' instead. However, Derry is quick to highlight that any causal *means* remains a relation, nonetheless. Such an explanatory strategy does not do away with the relation problem but defers it. To explain why Wertsch's appeal to a 'means' in meditation remains problematic requires some further unpacking. Derry

[41] This reference to Wertsch's book *Voices of the Mind: A sociocultural approach to mediated action* serves as the theoretical framework that Mortimer and Scott operationalise in developing their meaning-making framework. Thus, the central argument Derry poses to Wertsch's theoretical assumption has implications for the meaning-making framework, albeit seemingly distant from concerns of teaching and learning in science classrooms.

provides a powerful and in-depth critique of Wertsch's readings (Derry, 2013a, 2016; 2008). However, I limit my account here to the main thrust of her argument, derived from Brandom's inferentialist critique of relational or causal explanatory strategies.

This inferentialist critique is underpinned by the distinction Brandom draws between causes and reasons. As discussed above, the Pittsburgh School of Philosophy, including inferentialism, take issue with Cartesian and traditional epistemological assumptions underpinning much of contemporary analytic philosophy (i.e., nature of language, mind and meaning). Brandom considers explanatory strategies underpinned by such epistemological positions as belonging to the *representational paradigm* (2001, p. 7). Following Brandom, he shows how the *representational paradigm* refers to a particular epistemological position that assumes 'the relation of mind to world as one in which knowledge caused by sense experience is made meaningful by the constructions that are put upon it.' (Derry, 2013a, p. 32). Central to Derry's critique of Anglo-American scholarship is demonstrating how Wertsch's sociocultural account of language, mind and meaning falls under this representational paradigm[42]. In view of Brandom's distinction between representational and inferential paradigms introduced above (§4.1), Derry detects in Wertsch's conception of *mediation* an 'implicit dualism', derived from an appeal to a causal relation, which neglects the role of reasons (Derry, 2013a, p. 32). Derry is well aware Wertsch would immediately reject being classed under this 'representationalist paradigm'. If the charge of dualism is simply understood in terms of a correspondence relation that subscribes to a Cartesian epistemology, as some

[42] I recognised this problem through my own fieldwork in primary classrooms, which changed my approach to research (see introduction).

inner mind reflecting (representing) an external world – a representational view[43], this would be the very criticism Wertsch levelled against Vygotsky. So, how does Derry's charge of representationalism differ from Wertsch's Enlightenment criticism of Vygotsky?

Brandom's paradigmatic distinction identifies a trend in analytic philosophy that privileges the role of representation or causal (or pragmatic) relations in explanatory accounts. Derry employs this distinction to spotlight how Wertsch's understanding of mediational means constitutes a representational approach and consequently his view suffers an under-theorisation of agency and human freedom (Derry, 2013a, p. 36) in an account of mind and meaning, asserting that:

> Providing a 'mechanics' of mind for post-Vygotskian research is difficult because it raises fundamental questions about the nature of meaning, knowing and agency for which there are no settled answers. (p. 44).

In recognising the challenge facing representational explanatory strategy, Brandom offers inferentialism as an alternative paradigm that reverses the order of explanation. An inferentialist approach prioritises human activity as a distinctive inferential activity involving *reasons* in matters of meaning, communication and understanding. His inferentialist description takes as a point of departure our reasons, freedom and agency expressed in rational judgments in response to the world and others in thinking, saying and doing. As I move on from Derry's philosophical critique of Wertsch's reading of Vygotsky, I address Brandom's

[43] This rejection should come as no surprise, as this was precisely the charge Wertsch levelled against Vygotsky and his rationalism and semantic theory. Wertsch erroneously ascribed to him an allegiance to Cartesian epistemology (Derry, 2013a; 2008) and a referential theory of meaning (Wertsch, 2000), used to justify his formulation of a *post*-Vygotskian theory (see Chapter Three).

inferentialism not only as an alternative paradigm but as a theoretical framework in re-interpreting Vygotsky's concepts of mind and meaning.

4.3 Inferentialism: An Alternative Theoretical Framework

Brandom refers to his philosophy of language as inferentialism. As an epistemological framework, it offers a non-representational alternative to the representationalist paradigm in analysing human language and communication and explaining mind and meaning. Consequently, it opens other avenues in theorising our social and discursive practices. In introducing Brandom's inferentialism, I illustrate how it offers a theoretical reorientation of three key themes common to theorising classroom talk, learning and meaning-making:

(i) **Language:** the nature of our language and communication is reframed as a distinctive game we human knowers play. For Brandom, we are distinctive creatures engaged in concept-using practices. This distinctive practice is expressed as *the game of giving and asking for reasons*.

(ii) **Meaning:** the nature of our conceptual content, word/concept-meaning, or knowledge is related to the role concepts play in reasoning (*inferential semantics*)

(iii) **Social Interactions:** the use of concepts in our social and discursive practices in coming to know and understand relates to the rules of the *game of giving and asking for reasons*. (*normative pragmatics*)

As I discuss how this philosophical theory bears relevance in reorienting the key concepts, I also illustrate how limitations of representational approaches are made visible and self-evident. While I introduce Brandom's inferentialism and his semantics in brief below, it is in the next chapter that I discuss these ideas in relation to the primary science classroom. In Chapter Six I introduce Brandom's version of pragmatics. I then discuss this in relation to Mortimer and Scott's communicative analysis in Chapter Seven.

4.3.1 Brandom's Inferentialism: Language as a Distinctive Human Game

Crucial to Brandom's inferentialist account of human communication and linguistic meaning is recognising the distinction between sentience and sapience as a 'bright line' (2019). We, humans, are endowed with *sapience* or awareness. We are not simply *awake; we* are *responsive*, not just to *causes* or stimuli but to *reasons*. An account of human communication, language and meaning involves coming to understand humans as rational 'concept-using creatures'. Our interactions with the world and each other are always already conceptual in nature. This is not to say we somehow inherit concepts fully formed but rather an explanation of language should be in conceptual terms, that is, in *inferential* terms of what we do in our thinking, talking and acting from a first-person perspective animated by and for reasons. An inferentialist approach moves from naming surface-level relations and processes (representational) to peer beneath the surface and provide a descriptive account and vocabulary for what is an implicit dimension in our explicit social and discursive practices. Brandom claims that whereas psychological and empirical studies are concerned with how the trick of concept-use is done, philosophers are concerned with 'what could in principle count as doing it—a normative rather than an empirical issue.' (2009, p. 222). According to Brandom, our linguistic communication, *speech acts,* and social interactions are all part of a distinctive game we, as rational creatures, learn to play. Brandom's phrase is the *game of giving and asking for reasons* (GoGAR). This 'giving of' and 'asking for' reasons just *is* what we humans *do* in engaging in our social interactions and discursive practices. Key to Brandom's approach here is that any social interaction is by its very nature conceptual involving rules or norms, but these are not separate from the game. It is through playing the game historically that norms are instituted and by the very same process modified. They are not fixed but dynamic in nature as with the nature of the game. Take for example, the term ‘sick’, which means feeling unwell but has been modified by younger generations to mean something positive. A more scientific example is our understanding of the term ‘planet’. Through on-going debates and dialogue (a game of giving and asking for reasons), the role of the concept functions within a modified set of rules and subsequently led to the demotion of Pluto from a ‘planet’ to a ‘dwarf planet’ (c.f. see Chapter Nine). It is, of course, possible to create imitations of such human interactions. For example, when chess grandmaster Kasparov lost to a computer, he left the table without looking back. Put differently, the computer is not invested in the game, in the way Kasparov clearly was. He is responsive to reasons in playing the game in ways the computer is not and consequently responds differently. It would seem computers succeed in doing what we humans do in playing chess - moving pieces in response to other moves. However, Brandom’s point is that computers, even sentient beings, are not *aware*, in the sense of being concept-using rational free agents of *participating* in the *inferential game of giving and asking for reasons*. We, homo sapiens, engage in the practical activity of making judgements in reasoning and responding. It is our capacity for reasoning, our autonomy in making our own judgments, that is expressed through our thinking, talking and doing. Derry argues that this *inferential* dimension within our social practices remains under-theorised in Wertsch’s sociocultural accounts of communication and meaning. Consequently, what falls out of the picture is an inferential account or vocabulary that describes what we concept-using creatures do in linguistic communication i.e., giving and asking for reasons. Returning to our computer chess player, for example, it also follows procedures, performs acts and imitates what we humans do but all without doing what we distinctive humans *do* (inferentially), that is, engage in making judgments or inferences (reasoning), more specifically, this is undertaken through playing the 'game of giving and asking for reasons' with others.

For contrast, let us take Brandom's well-established example of a parrot that squawks, 'It's red!'. According to Brandom, the parrot does not *understand* its own squawk as a claim or response; it is not an *assertion* – of a belief, authority or possibility (2001; 2009). He claims that our human responses, our sayings, doings and believings are already and always conceptual; it is not merely a mindless act, performance or response. Considering humans as rational, concept-using and meaning-making creatures, Brandom claims '...for a response to have *conceptual* content is just for it to play a role in the *inferential* game of making claims and giving and asking for reasons.' (Brandom, 2000, p. 48). For Brandom, when we humans make a claim or an assertion of some sort, we are aware and understand what such a claim follows from and what claims may or may not follow from it. For example, 'It is red' entails 'it is not blue' and 'it has a colour' or 'is visible' and so on. Thus, all our concepts and claims are related to numerous other concepts and claims. These relations made between concepts or claims constitute our *reasoning* in thought or talk, an *inferential* practice of *relating* claims with other claims, in a web of inferences. Our distinctive capacity for reasoning or making judgments in discursive practices not only involves making and drawing inferences but also offering or demanding reasons in justifying claims we take on and assertions we make. In this sense, our conversations and actions involve a certain responsibility and accountability, distinguishing them from acts based on input/output, causes-effect or differential responses (e.g., a thermostat responding to temperature or a smoke detector sounding an alarm). For Brandom, assertions or claims are not mere utterances or audible vocalisations, such as the parrot squawking. Assertions express our rational judgments and, in social practices, articulate reasons. Taking all human activity as inferential activity, which we free and rational agents engage in, demarcates inferentialism from representationalism as a distinct paradigm. This inferentialist principle informs his approach to theorising meaning (inferential semantics) and action or communication (normative pragmatism).

4.3.2 Brandom's Theory of Meaning and Communication

Children learn a language through participation. As they talk with others, they begin to appreciate the right and wrong ways of saying or using words. In learning a language, as soon as the child's utterance expresses more than noise, she begins to legitimately participate in the *game of giving and asking for reasons*. Through playing the game, they develop a certain awareness or *responsiveness* to the rules of the game. For example, in learning to use the word 'duck', in using the word, she begins to engage in the process of confirming she is applying the concept in the correct ways, taking something to be a 'duck' and not a 'truck'. In other words, she is confirming the correctness of her judgment in applying the concept – its practical use. As Derry expresses it, the word/concept is 'meaningful to the extent she has reasons for the *use* of the "noise" or utterance, by virtue of having a sense of what follows from and what supports the utterance' (2013a, p. 82). Through talking with others and playing the game, she is able to *calibrate* the meaning of words. She begins to *master* concepts through their *use* by undertaking the beliefs or inferences deemed permissible and weeding out those that are not. For example, coming to understand the *meaning* of the concept 'spoon' entails a host of related ideas or inferences, such as ‘it has a handle’, ‘it is blunt’, ‘you can scoop up liquids with it’ etc. In other words, coming to understand a concept or word is coming to understand the *inferential or consequential relations* that constitute its use or *meaning.* In playing the game, a player takes responsibility for the moves they make and the beliefs they attribute to their own concepts/words in becoming responsive to a particular set of reasons that constitute their use of the concept. This responsibility refers to a ‘semantic responsibility’ in coming to grasp a concept through its use in discursive practice. This involves understanding how to situate related responses or claims in a network of *inferential relations* (Bransen, 2002). Brandom expresses this conceptual grasp or understanding in his own words as follows:

> To grasp or understand such a concept is to have practical mastery over inferences it is involved in–to know, in the practical sense of being able to distinguish (a kind of know-*how*), what follows from the applicability of a concept, and what it follows from. (Brandom, 2000, p. 48).

The word/concept taken as a claim serves as a move in the game of giving and asking for reasons – ‘a move that can justify other moves, be justified by still other moves, and that closes off or precludes still further moves’ (Brandom, 2001, p. 162). These moves or *inferential relations* constitute the meaning of concepts or words used in discursive practice. In playing the game, coming to know a concept involves grasping the inferential role a concept plays in reasoning and becoming responsive to what claims an utterance follows from and what claims follow from it. It is in this sense that Brandom claims that ‘in order to master *any* concept, one must master *many* concepts’ (ibid.).

Brandom's semantic theory considers the inferential role of words or concepts in reasoning – as a kind of rule governing the correct use or application of a concept as constituting meaning or conceptual content. His semantics is an *inferential semantics* and, as a theory of concepts, forms a key part of his philosophy of language. Peregrin claims Brandom's distinctive approach to language, rooted in Hegel, can be roughly characterised by his conviction that 'to be meaningful, in the distinctively human way, or to possess 'conceptual content', is to be governed by a certain kind of inferential rules.' (Peregrin, 2013, p. 1082). Where these rules are understood as norms, this view, Peregrin claims, could be compressed into the slogan *meaning is normative* (ibid., p. 1083). He is quick to caution, however, that such compression may mislead on the ground that 'the point at issue is not that meaning is a specific, normative kind of thing, but rather that meaning is not really a thing at all, for the talk about it is not really a description'. (ibid.). He highlights the way Brandom accounts for meaning in terms of use or functionalism, but more specifically, as a *normative* functionalism. Put simply, in addressing the role of judgments and reasoning entailed as constituting meaning, he puts a normative spin on discursive practices or meaning-making processes, viewing inferential activity as a norm-governed activity or normative practices.

In using language and concepts in social practices, we engage in *endorsements*, that is, in instituting *norms* or *rules*, that not only attend to how things are but how they *ought* to be (Bransen, 2002). Endorsements are the correct and incorrect ways of taking something to be a certain way. For example, I share with other humans that an appropriate way to use a spoon is by placing it in my mouth and not up my nose. Our behaviour is not reinforced by regularity but rather by our conduct, which is governed by norms that we socially or collectively institute

(Bernstein, 2010; Bransen, 2002, Derry, 2017; Peregrin, 2014). It is the norms we endorse as a community that determine the right and wrong ways of thinking, saying and doing things. Our discursive practices are not only social or mutual but *normative,* extending beyond mere social convention to appeal to our nature as norm-governed, concept-using, meaning-making creatures *responsive to reasons,* not just causes and constrained by norms and not just the material world. Thus, rules not only govern what we do but what we say and how we think. In recognising our rule-governed practices and rule-following behaviour, Brandom develops his distinctive *normative pragmatic* account of our discursive practices (Brandom, 2000; 2011, Loeffler, 2018).

Thus far, Brandom's philosophy of language attends to us humans as autonomous reasoning creatures who engage in linguistic communication viewed as participation in the game of giving and asking for reasons. On the one hand, his inferential semantics accounts for word/concept meaning (conceptual content) in terms of our discursive practices as an expression of our rational freedom as judging, reasoning, and language-using creatures. On the other, we are social, normative creatures bound by rules that we collectively and socially institute and freely bind ourselves to (Derry, 2017). Our discursive practices express our rational freedom in using concepts in rule-bound activities. Discursive practices as norm-governed are normative practices. Inferentialism offers an alternative theoretical framework that reorients crucial ideas relevant to meaning-making research, which Derry encapsulates in her analogy of a kaleidoscope, claiming:

> For what we have with Brandom is a 'turn of the kaleidoscope' where familiar elements in an epistemological account are reconfigured and assume a new

> shape. ….. this reconfiguration can play a positive part in thinking about educational issues, such as the structure of knowledge. (Derry, 2013b, p. 231)

This epistemological turn in an account of meaning (semantics) and communication (pragmatics) has implications for sociocultural interpretation of language and meaning in which the meaning-making framework is grounded, which I address next.

4.4 Inferentialist Reorientation of Classroom Discourse

In developing his sociocultural framework, Wertsch considers his work as accomplishing the project Vygotsky initiated but left incomplete. His post-Vygotskian perspective involves applying 'Bakhtin's ideas, in particular, *utterance, voice, social language, and dialogue,* to extend Vygotsky's claim about the mediation of human activity by signs.' (Wertsch, 1991, p. 17). Mortimer and Scott's research framework successfully operationalises Wertsch's sociocultural theory by applying Bakhtinian concepts in analysing classroom discourse. They achieve what Wertsch claims is absent from educational semiotic research, which is to '…integrate the various functional orientations of language recognised by Vygotsky into an overarching framework' (1996, p. 41). However, what is crucial from an inferentialist perspective, is the recognition that these post-Vygotskian approaches assume Vygotsky was constrained by his epistemological commitments that located meaning in words or concepts. Subsequently, his focus on language and semantics is considered as neglecting the pragmatic dimensions of language-use. As I discuss Mortimer and Scott's framework, I draw a distinct contrast between their sociocultural approach and Brandom's inferentialist framework. I explore how an inferential re-orientation illuminates the nature of language and its analysis focusing on three key themes:

the nature of language, the character of communicative activity and the unit of analysis of dialogue.

4.4.1 Classroom Discourse: A Sociocultural Interpretation

In thinking about the role and nature of language in classrooms, Wertsch turns to Bakhtin’s notion of *social language* for inspiration. For Bakhtin, there are many ‘social languages’, and for ‘Bakhtin, a social language is “a discourse peculiar to a specific stratum of society (professional, age group, etc.) within a given social system at a given time”’ (Holquist and Emerson, 1981, p. 430 cited Wertsch, 1991, p. 57). Utilising this concept of ‘social language’, Wertsch distinguishes between ‘social’ and ‘national’ languages. A particularly fitting distinction given his focus on ‘multicultural schools’ that involve a range of different subjects, each with their distinctive ways of talking about their respective domains (e.g., Science, Mathematics or English). He highlighted that where *social languages* might differ, the *national language* does not (Wertsch, 1991, p. 56). Social language as a theoretical concept provides a lens through which to characterise the peculiar and distinctive discourse of school science in science classrooms. For Mortimer and Scott, *social language* refers to the *school science* talk, concerned with the content and ways of talking within the science classroom as a community in which language-users participate.

However, Bakhtin's influence leads Wertsch to view linguists as preoccupied with linguistic form and meaning, as objects of study abstracted from their context of use. This is a criticism Wertsch directs at Vygotsky, identifying him as overly committed to semantics understood as a branch of linguistics. In contrast, Wertsch considers Bakhtin’s analysis of language as concerned with the *use* of words and sentences in their actual context, captured by his concept of *utterance*, which is considered ‘the real unit of speech communication’ (Wertsch, 1991). As we saw in the last chapter Wertsch understands that ‘[a]ny utterance involves at least two voices: the voice producing it and the voice to which it is addressed (Wertsch, 1991)’ (Mortimer and Scott, p. 121). For example, consider the short extract from a classroom dialogue below:

1. Mrs. Simon: ... what are forces? Jessica.
2. Jessica: A push or a pull?
3. Mrs. Simon: Yeah! Pushes and pulls ...

From a linguistic view, the dialogue is analysed as a series of turns (e.g., 1,2,3 etc.), which can be assessed and coded (see Chapter Seven for details). For Wertsch, ‘when a speaker produces an utterance, at least two voices can be heard simultaneously’ (1991, p. 13). So, whereas turn 2 is a linguistic performance made by an interlocutor, as utterance, it is not just a linguistic entity but expresses multiple voices or is characterised by a ‘dialogicality of voices’. Jessica’s utterance is not just a linguistic statement but an expression of her voice or ideas as well as the teacher’s voice or scientific ideas. Thus, any study of classroom talk must necessarily recognise the role of *utterance* as a minimal unit of analysis.

Wertsch considers our language-use as embedded within social languages, within specific social and cultural contexts, belonging to a particular community of language-users, for example, in science classrooms. In their analysis of classroom discourse viewed through a sociocultural lens, Mortimer and Scott also attend to Bakhtin’s concept of *speech genre,* concerned with the distinct *style* of utterances produced. Operationalising Bakhtin’s ideas lie in understanding that *social language* ‘is related to a specific point of view determined by a social or professional position’. At the same time, *speech genre* is ‘related to the social and institutional place where the discourse is produced.' (Mortimer and Scott, 2003, p.130). Thus, speech genres capture specific patterns within disciplinary discourse, which contribute to Mortimer and Scott's sociocultural analysis of science classroom discourse. The utterances serve as the unit of analysis, identified by turn-taking practices and other identifiable speech features such as the IRE and IRF patterns of discourse[44] and their communicative approaches analysis (see Chapter Two).

4.4.2 Classroom Discourse: An Inferentialist Orientation

Derry's retelling of Vygotsky's account of meaning and communication sits in contrast with Wertsch's post-Vygotskian story. Turning to Brandom's philosophy of language – inferentialism, she alerts us to neo-Hegelian developments in approaching human communication and dialogue as more than merely a linguistic or pragmatic affair but as a distinctly human affair, involving what humans *do* in thought and talk, that is *reason*. In analysing human discourse, it is simply not enough to attend to language as structures, patterns or utterances alone. According to an inferentialist view, our discursive practices involve rational beings playing the *game of giving and asking for reasons*. As a matter of priority, the focus must necessarily shift to emphasise our reasoning, rational freedom, and *judgements* expressed in thought and talk. Brandom analyses discursive practices[45], taking this metaphor of a game 'as seriously and literally as possible' (Bransen, 2002, p. 387), which means an account of thought and talk framed in terms of rules and moves, but also scores, players and keeping score.

[44] This patterns of discourse as IRE was addressed in the historical background (see Chapter Three). Details of IRF and IRE will be addressed in the analysis chapters (see Chapter Seven).
[45] Disclaimer: Just as a side note remember though we are paradigmatically dealing with linguistic performance, it need not necessarily only pertain to verbal exchanges. The notion of *pragmatic significance,* allows the application of this account to be rendered to any form of communicative exchange where norms and scores are in play, such as gestures, models etc.

Language: As a Game and Its Rules

Peregrin renders inferentialism in more accessible terms by drawing an analogy with playing a chess game[46]. Our language games and linguistic practices are like playing by the rules of chess. For Brandom, discursive practices are essentially norm-governed social practices (Brandom, 2000; Loeffler, 2018; Peregrin, 2014). Put differently; our discursive practices are bound by rules (norms), rules we collectively socially institute and are obligated (*deontic*) to follow in participating in linguistic exchange (Derry, 2013a; Loeffler, 2018). Without such rules, we would not be able to engage in discussion. Our language games require rules for us to participate collectively in a coherent manner that allows us to communicate with each other successfully. For example, just imagine playing a game of chess where there were no rules that regulate the moves of chess pieces, or a chequered board used to constrain and position moves. It would cease to be a game of chess at all, nor would it be possible to participate in playing the game with others. However, these rules as norms are not commands, such as those that govern the way a computer plays chess. The *rules* of chess have the character of *constraints* as opposed to *commands*. These *rules* do not tell players how to move chess pieces at a particular moment of the game. They neither prescribe nor command but constrain the player in freely making or responding to a move. Likewise, the rules of Brandom's game do not tell us or advise us on how to use the words. It does not determine what we say in dialogue but serves to determine whether moves or claims made are legitimate or prohibited. For example, the rules of everyday language permit me to call and talk about tomatoes as a vegetable. However, within the science classroom talk a tomato

[46] Although Brandom makes use of this analogy, Peregrin focuses on making the details and correlation of this analogy more explicit (Peregrin, 2014).

should be classified as a fruit. This is not to say it would not be possible to classify tomato as a vegetable, but rules governing the knowledge domain of science make it illegitimate, whether one is aware or not. The rules of the language game we play are different and constraints on terms and claims, such as ‘tomato’, are much tighter. This may seem rather unproblematic but regardless, there are still reasons in play. My point is that it is when issues become problematic these implicit reasons need to be made explicit in coming to resolve the problem. Conversely, in the classroom, the teacher may employ these reasons to deliberately problematise an activity, such as the classification of sand in order to make the implicit reasons functional and explicit in thought and talk in class discussion and activities. The rules in Brandom’s language ‘prohibit’ such claims or beliefs; making such assertions in the game would be inappropriate or incorrect but, of course, possible. These rules for Brandom seek to convey the ways in which our language and concept use are governed and constrained in systematic ways but not necessarily in a fixed or rigid manner. Chess as a game has evolved along with its rules. For example, castling is a perfectly permissible move in accordance with the rules, but these rules have been adjusted and modified not by the game itself but by the players of the game and in the way the game is played.

Richard Feynman gives an example in his autobiography of how he found the symbols used in mathematics tedious and so devised his own. He did not think it made a difference, but it did. It was only when he started explaining the math to another student Feynman says, ‘I realized then that if I’m going to talk to anybody else, I’ll have to use the standard symbols, so I eventually gave up my own symbols.’ (Feynman, Leighton, Hutchings, 1997, p. 12). The rules governing the game of giving and asking for reasons in any given knowledge domain or discourse are structured, systematic and logical, and make up the coherent system of claims. It is in this sense that Vygotsky claimed that:

> Only within a system can the concept acquire conscious awareness and a voluntary nature. Conscious awareness and the presence of a system are synonyms when we are speaking of concepts, just as spontaneity, lack of conscious awareness, and the absence of system are three different words for designating the nature of the child's concept (Vygotsky, 1987, pp. 191-192).

Although they are logical rules, they bind us and constrain our moves not by necessity nor compulsion but by a certain obligation in communicating successfully with others. These rules as norms govern the way we think speak and act in a given knowledge domain, but they are not rigid fixed systems, in fact they are systems of our making and a product of a collective historical development, just as with the rules of chess, understanding the concept 'planet' and its application in naming and classifying celestial bodies. In Derry's own word she states quoting Brandom (1994):

> It is our capacity to be responsive to reasons and not simply caused to respond that allows our actions to be constrained by norms that we have collectively put in place, rather than by unmediated nature. Brandom, clarifies the basis of this freedom when he states that "The laws of nature do not bind us by obligation, but only by compulsion. The institution of authority is human work; we bind ourselves with norms" (p. 51). (Derry, 2017, p. 411)

Here, the contrast between sociocultural perspective and inferentialism emerges more clearly. The sociocultural approach distinguishes between everyday and scientific discourses appealing to the concept of *social language,* which rests on the linguistic content (language) and the social and cultural context or circumstances of language use (pragmatics). From Mortimer and Scott's sociocultural perspective, Vygotskian referential semantics was out, and Bakhtinian linguistic pragmatics was in. The argument advanced from an inferentialist perspective reorients an understanding of social and cultural context as *normative constraints*, as rules governing the *use* of terms, claims and beliefs expressed in discursive practices. By foregrounding this *normative* dimension in describing discursive practices, Brandom posits his *normative pragmatism*.

In playing chess, it is the *rules* that make pieces of wood into a bishop, pawn, or knight and not the pieces themselves. There is nothing inherent in chess pieces that determine their role in the game. It is the rules that 'constitute the role conferred' to such pieces in playing the game. In the same manner, it is not words themselves that are *already* meaningful but rather 'the words acquire the meanings *via* being subjected to the rules.' (Peregrin, 2014, p. 109). The norms are fundamental to an account of discursive practices (pragmatics) and word or concept meaning (semantics). It is from this perspective that Brandom makes his proclamation that 'semantics must answer to pragmatics' (2000, p. 185). By this crucial inferentialist reorientation of language, meaning and communication, Derry can bring the Vygostkian semantics, rejected by Wertsch, back into the fold in an account of thought and talk of the classroom.

Utterances: Minimal Unit of Analysis or a Move

From an inferentialist view, words or concepts are expressed in thought or talk by 'knowers and agents, ones who are *responsible* for their doings and attitudes. What they are principally responsible for is having reasons for those doings and attitudes'. (Brandom, 2009, p. 3). To return to the chess analogy, playing the game not only involves rules but an acknowledgement of players who make moves in responding to other moves in playing the game. These *rules* are not just made up in the spur of the moment but socially instituted, endorsed and followed by the players, whether it be a game of chess or domain-specific language. In playing the *game of giving and asking for reasons*, there are always norms and conventions a player must respect and follow. They are obliged to follow these rules if they wish to be considered a legitimate player of the game. We are free, rational beings, but we nevertheless have a duty or responsibility in playing the game and are held responsible by other players. According to Brandom, we as rational agents are responsible, and we take responsibility, and 'the minimal unit of responsibility is the judgment' (Brandom, 2011, p. 3). Judgements are 'things we are in a distinctive way *responsible* for. They are a kind of *commitment* we undertake' (ibid.). In reorienting the nature of language as a game, it is considered not only as social but as a rational and normative practice – a *deontic* practice. The analysis of our discursive practices rest on the fundamental unit of responsibility of players in playing the game of giving and asking for reasons[47]. This responsibility is tethered to our rational judgments; commitments players undertake in 'producing and consuming reasons' (2000, p. 14). Wertsch,

[47] Brandom has a sophisticated account of how we as players participate and keep scores in making moves and playing the game in deontic practice, which he refers to in his favourite idiom of deontic scorekeeping. I developed a detailed account of his scorekeeping approach to discourse analysis illustrated in Chapter Six, following his inferentialist semantics presented in Chapter Five.

following Bakhtin, stops at utterances as the minimal unit of analysis. Brandom, however, takes our discursive practices as involving minded creatures engaged in giving and asking for reasons, and peers beneath the linguistic plane to attend to the rational and normative dimensions of the games we concept-using creatures play. While inferentialism acknowledges a unit of analysis, Brandom's approach in analysing discursive practices reorients an understanding of what this concept involves. This is a discussion I develop from the next chapter onward and conclude in Chapter Seven. Brandom has a sophisticated inferentialist account of our rationality and semantics, which Derry's scholarship relates to Vygotsky's mind and meaning. His finer-grained analysis of language and meaning, while it offers a pragmatic account of our linguistic communication, Brandom proceeds by acknowledging the inferential dimensions and appealing to normative vocabulary in describing moves players make in discursive practices. I discuss this vocabulary in more detail in the next chapter. His focus on the inferential dimension sits in contrast to the representationalist strategy that appeals to a mediational means or representation in analysing our discursive practices. The crucial problem that Derry highlights, inspired by Brandom and the Pittsburgh school of philosophy more broadly is that such representations or relations derive from an implicit dualism, which leaves the relations themselves in need of explaining. Introducing Brandom's inferentialist approach, which privileges our mindedness, rationality and normativity in an explanatory account of linguistic practices, avoids issues of dualisms and world-mind or reference relations issues that plague explanatory strategies that fall under the representationalist epistemology or paradigm. Crucial to this inferentialist alternative is how it 'turns the epistemological kaleidoscope'. In short, it takes familiar concepts or terms and reorients them, operating with different presuppositions and opening up alternative perspectives, which has implications for theorising and analysing meaning-making and pedagogic practices in classrooms.

Summary

In sum, the chess analogy illustrates how inferentialism views language as constituted by rules and dialogue as 'norm-governed practices'. The analogy identifies the *rules* of chess with the normative constraints on our reasoning in thinking, talking and acting in using words and concepts in linguistic activity. The rules govern what the pawn can do in a game of chess, but not the player and what the player does with the pawn in playing the game and freely making chess-moves in response to other chess-moves. Knowing the rules does not compel us or tell us how to act or talk but only what we should or 'ought' to do, they are normative in nature, and our communicative exchanges are social and normative or *deontic* practices. In this reorientation from Anglo-American Vygotsky scholarship to contemporary neo-Hegelian thinkers, such as Brandom, I have addressed three key themes of language, communication and analysis, expressed in inferentialist terms:

1. **Game:** The language game, as a rational *game of giving and asking for reasons*, still retains a representational structure, but inferentialism illuminates the limitations of representational approaches that focus on linguistic structures while neglecting inferential dimensions. I illustrate how inferentialism shows how attending to surface features of language does not do justice to the nature of human communication and our meaning-making.

2. **Rules:** Starting from an inferentialist acknowledgement of our discursive practices as a normative affair, I illustrate how attending to the *rules* of the game or *norms* that govern discursive practices make visible dimensions of

that language game that are overlooked and thus remain under-theorised in classroom talk research.

3. **Moves:** Inferentialism not only addresses rules but also acknowledges the *role of players* as concept-users. Thus, meanings are not located in representations but in inferential relations that constitute the norm-governed use of the concepts in socio-normative or *deontic* practices.

According to inferentialism, meaning is not determined referentially; it does not ‘stand for’ or *represent* something else, nor is it to be explained by appealing to such representational strategies. Since ‘meanings are utterly a matter of rules’ of the game being played, meaning lies in grasping the rules that govern the use or application of a concept in thought and talk, not merely its reference or relation to the word or some definition. Inferentialism takes our thinking and speech as expressing our rationality as fundamental. In giving pride of place to reasoning and judgments made by concept-using creatures in an explanatory account of language, meaning and communication, inferentialism sits in stark contrast to representational accounts, such as sociocultural theory.

A critical insight for the present thesis is that inferentialism does not simply buttress representational approaches. By attending to our rational judgments (inferences), constrained by norms of our intersubjective socio-normative discursive practices, it offers an altogether alternative framework. To fully grasp the power and implication of this thought in an account of our thought and talk requires further investment in developing these ideas in relation to the practicalities of the science classroom. Thus, I turn now to consider a scenario in teaching primary science.

PART II: Analytic Considerations

5 Classification of Materials: Towards an Inferentialist Approach

In this chapter, I illustrate Brandom's distinctive inferentialist account of meaning and concepts and how it illuminates teaching and talking science with children in coming to understand science concepts. I focus on the primary science topic 'Materials' and the challenges primary teachers face in discussing materials with children and developing a scientific understanding of the various properties materials display. Grouping and classification are common pedagogic approaches to teaching materials in primary science. This practical activity in classroom contexts offers a point of entry for illustrating certain technical aspects of an inferentialist theory of meaning (semantics) and how it can inform primary teaching and classroom dialogue in science lessons as a theory of concepts. I discuss Brandom's view of concepts and meaning, his *inferential role semantics*, in relation to the classification of materials and illustrate how an inferentialist approach and practical resources could be employed in planning and teaching materials. An inferentialist interpretation of the nature of concept-meaning entails critical discussions related to the meaning-making concept and classroom talk, which I develop in subsequent chapters. The present chapter focuses on introducing some fundamental inferentialist ideas as prerequisites for addressing the issue of intersubjective communication and the analysis of classroom talk and meaning-making framework more specifically.

5.1 Understanding Materials in Primary Science

The study of materials constitutes one of science's 'big ideas' (Harlen, 2010; Skamp and Preston, 2015). However, teaching about materials is also considered one of the 'tricky bits' of the primary science curriculum (Rutledge, 2010). The most recent changes to the National Curriculum for primary science in England and Wales were published in 2013. In its present form, the concept of materials is directly addressed as a topic under 'Everyday materials' (Year 1), 'Uses of everyday materials' (Year 2) and 'Properties and changes of materials' (Year 5) (DfE, 2014). The illustrations and examples in the present discussion focus on upper Key Stage 2 science teaching in Year 5 classrooms.

5.1.1 Classification of Materials: Pedagogic Approaches

In talking to children about the material world, the primary teacher may identify all sorts of everyday objects, such as books, rocks, tables and chairs. In discussing what they are made of, it may seem pretty obvious to the teacher that these objects are either solid, liquid or gas. The study of solids, liquids and gases is a component of most primary science curricula and not only constitutes part of the concept 'materials' but also relates to other science topics within the curriculum such as 'States of matter' in Year 4 or 'Rocks' in Year 3. While primary science resources offer various activities, such as card sorts[48], concept maps[49] or concept cartoons[50], I

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[48] Card sorts is an activity that involves a collection of cards, for example, with pictures of different materials that are required to be sorted into groups such as 'solids', 'liquids' or 'gases'. Card sorts are commonly utilised as a form of 'non-verbal' approach considered 'more accessible to learners with lower literacy skills' or pupils who 'use English as a second language' (Allen, 2010, p. 9).

[49] There are various concept mapping techniques. The most basic approach involves selecting words related to a particular topic, such as Materials. Pupils arrange words on a large sheet of paper. Associated words are connected by a line and accompanied by a comment explaining the connection. For example, 'Sand' and 'Wood' are related because they are 'Both solids' (Allen, 2010, p. 9).

[50] Naylor and Keogh present the idea of concept cartoons in their well-known book Concept Cartoons in Science Education (2010). A cartoon presents different characters expressing different views about a situation related to a scientific topic e.g., a snowman melting with four different views in speech bubbles. The activity

choose to focus on classification as it is not only a common approach but a persistent feature amidst the historical[51] changes made to the primary science curriculum (Allen, 2010; Cross and Bowden, 2014; Rutledge, 2010; Skamp and Preston, 2015).

Classification is widely recognised as forming a crucial part of primary science teaching. A common approach in teaching and talking about materials is their classification into solids, liquids and gases categories (Allen, 2010; Rutledge, 2010; Cross and Bowden, 2014). However, viewing these classifications as clear-cut categories in teaching about materials and their properties is likely to raise challenges in teaching and talking to children as they come to understand target concepts in more scientific ways. Certain materials, for example, readily fall into clear-cut discrete categories, such as wooden blocks, metal coins, water and air. The difficulty emerges when classifying certain everyday items that are more 'atypical' materials[52], such as toothpaste, foam, sugar, jam, or fizzy drinks (Levinson, 2000; Skamp, 2015). The 3-fold categories quickly become blurred or confusing, not only for children but for primary teachers as well. So how are teachers to deal with materials which do not readily fit into the solids, liquids and gases (SLG) framework? This problem has been identified and reported by decades of science education research and informs numerous science professional teacher development programmes and primary science teaching resources (Russell, Longden and McGuigan, 1991; Allen, 2010; Skamp and Preston, 2015). I review this pedagogic challenge below, discussing two approaches to teaching materials with classification.

serves to open up dialogue and the opportunity to elicit and engage with pupils' ideas and conceptions (Allen, 2010, p. 10).

[51] Classification has formed part of the primary science curriculum from at least 1999 to the present day.

[52] Atypical in terms of their material behaviour, which may nevertheless be 'everyday materials'. Typical examples I draw on are powders, jam, jelly, fizzy drinks, corn starch, foam, and aerosols.

Discrete Classification: A misconceptions approach

According to Allen's *misconceptions* approach (2010), in teaching about 'Materials and their properties' (p. vii), where solids, liquids and gases (abbreviated to 'SLG') are understood as different states of matter, and where pupils are in doubt, teachers should cite 'mutual exclusivity by asking them which set they think it belongs in the most' (Allen, 2010, p. 102). According to his view of learning, children 'construct mental models' in making sense of the world around them (constructivism)' (ibid., p. 6). In expressing his understanding of 'misconceptions', Allen claims that 'If these constructions conflict with accepted scientific ideas they are misconceptions, and act as a barrier, preventing successful learning in science' (ibid.).

Discrete Classification: Characteristics of Three States of Matter

Solid	Liquid	Gas
Has its own shape	Takes the shape of the bottom of its container	Fills its container
Cannot change its volume	Cannot change its volume	Volume can be changed (can be compressed)
Particles very close together and fixed in position in a regular pattern	Can flow	Can flow
	Can be spilled	Particles far apart, free to move randomly at high speeds
	Particles very close together and not fixed in position	

Table 3. Discrete classification

(Adapted from Allen, 2010, p. 101)

In support of his approach, Allen draws on a vast range of constructivist research within the science education literature, spanning over the last 45 years. In line with misconception literature, Allen recognises that SLG classification may pose difficulties for pupils deciding which category to place an object in. For example, a football may be classed under the category 'solids'. However, being hollow, it may be considered as belonging to 'non-solids' category, especially if one considers an everyday understanding of 'solid', as defined by the Oxford dictionary as 'not hollow or containing spaces or gaps' (Stevenson, 2010a). In the face of these difficulties, Allen advocates the discrete approach to classification. He claims that if pupils are ever in doubt about the state of a material, 'cite mutual exclusivity by asking them which set they think it belongs in the most. Get them into the habit of judging a material to be solid, liquid or gas with no intermediate sets' (Allen, 2010, p. 102, see Table 3. Above and Fig 5. below).

Discrete Classification of Materials

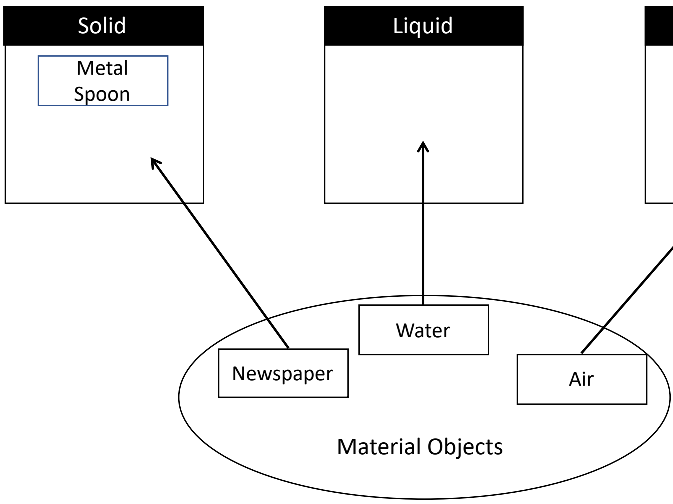

Fig. 5. Discrete classification

While Allen's approach serves a practical purpose for generalist primary teachers who may lack expertise in science, his approach has enjoyed endorsement in primary science teacher education (McCrory and Worthington, 2018). However, such prescriptions and views of learning restricted to the cognitive account are viewed in a more critical light by those who acknowledge the continuous nature of material classifications but also the social and discursive nature of learning, as discussed below.

Continuous Classification: A discursive approach

In contrast to the discrete classification approach, children's judgements and disagreements regarding the classification of particular objects could and should be used as an opportunity to extend the SLG classification activity instead of excluding them (Levinson, 2000; Skamp and Preston, 2015). The teacher could utilise these points of agreement and disagreement to encourage discussions on discrete classifications, their representation, limitations and possible alternative approaches to re-organising the classificatory mode. For example, the classification could be re-envisaged as a continuous spectrum or Venn diagram (See Fig.6).

Continuous Classification of Materials

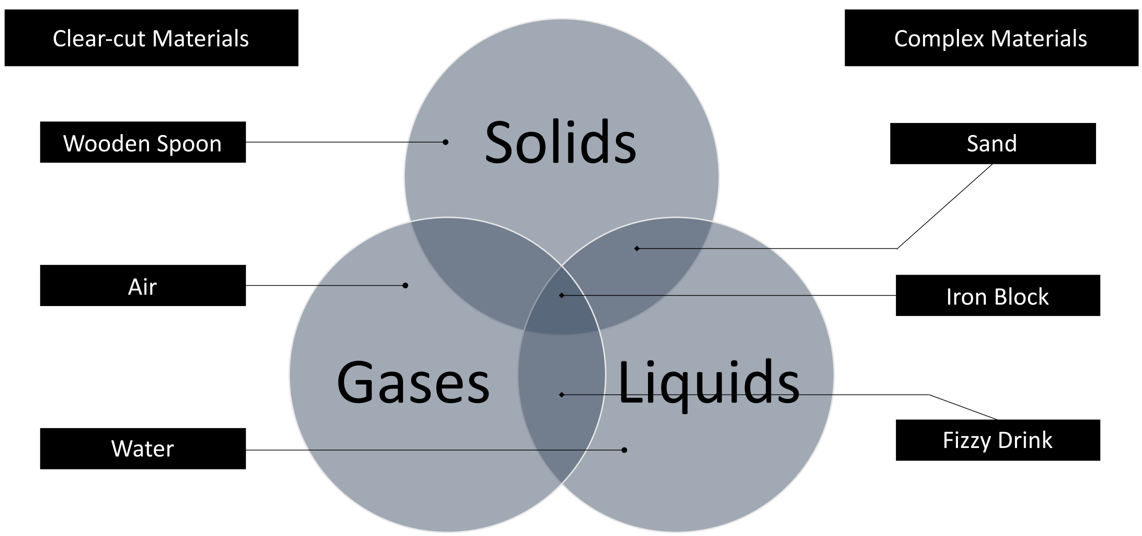

Fig. 6. Continuous classification

This approach was employed by Levinson (2000), who reports on running a workshop for trainee primary teachers, subsequently reported by Skamp and Preston (2014) as a strategy that contrasts with dialogic approaches that focus on classroom talk. His approach involved introducing different materials, including 'boundary' materials or *dilatants*, such as jelly, jam, or toothpaste. These materials display properties of both solids and liquids, which pose difficulties in classification for both teachers and children. The complexity of these materials in problematising the activity of classification encouraged deeper discussion and thinking through classifications and the concepts of solids, liquids and gases (Levinson, 2000; Skamp and Preston, 2015; Rutledge, 2010). According to Levinson, this process of problematising classification serves to engage children's *own thinking* about materials and the behaviour of materials. He gives an example of thinking through SLGs by presenting pre-service primary teachers with a block of iron. To the uninitiated, it is obviously a solid. However, in drawing attention to its distinctive odour, he highlights that it has a smell - a gaseous property. In presenting situations that blur the boundaries between solids, liquids and gases, he works with teachers in thinking about how to model the properties of solids, liquids and gases of different materials. In producing their own models to capture the various materials and SLG properties, the teachers generated a range of approaches, from a hierarchical scale to a flow-chart or decision-making process, a continuous spectrum, and the optimal model, a Venn diagram. The process of 'thinking through' the idea of classification helped teachers appreciate the way in which scientific definitions provide clarity to complex and confusing issues. The concept of solids, liquids and gases, when considered both as discrete states and continuous properties, allowed for discussion of the nature of classifications and scientific thinking as a human endeavour. The process enabled student teachers to acknowledge classification not only as having possible limitations but as negotiated by a community of scientists in developing a practical model, as opposed to reflecting some objective external facts belonging to the world.

This continuous approach to classification foregrounds the role of 'thinking' or reasoning in science teaching. The strategy complements dialogic approaches taking social interactions as central to concept development, where the teacher intervention is crucial in supporting children to 'thinking carefully about the consistency of their reasons'[53] in classifying unusual materials (Skamp and Preston, 2015, p. 323). Problematising the categories themselves and subsequent dialogue about the terms or concepts of solids, liquids and gases provides an opportunity for the teacher to bring pupils to a more scientific understanding of what is involved in thinking about materials.

5.1.2 Pedagogic Approaches to Classification and Teaching Materials

A crucial aspect of the continuous approach is not only the innovative Venn diagram but the subsequent talk it opens up with children about materials and the nature of material properties. Various teaching strategies and activities illustrate the integral role of language-use in 'facilitating conceptual development and change' in science classrooms (Skamp, 2015, p. 321). Teacher-talk and communicative approaches identified by Mortimer and Scott have been acknowledged and incorporated into numerous teaching strategies for facilitating pupils' conceptual development. While they are not alone in addressing forms of classroom talk or teacher talk (Barnes, 1976, Mercer and Hodgkinson, 2008, Mehan, 1979, Mortimer and Scott, 2003;

[53] The role of the teacher is what the discursive turn and meaning-making framework responds to. A central issue to the inferentialist perspective is the teacher's orientation to the knowledge domain conceptual content. The nature of 'consistency' of concepts and 'reasons' articulated in their use are significant issues in supporting quality discussions. This is an issue I discuss in the next chapter, which focuses on an inferential approach to discursive practices in view of concepts and development of concept meaning and conceptual understanding presented here.

Lemke, 1990; Newton, Newton and Blake, 2002), their framework remains one of the most widely influential approaches (see Chapter Three; Mercer and Dawes, 2014). Despite numerous and diverse approaches to teaching and discussing materials, there still remains considerable ‘contestation about the most appropriate pedagogical approach’ (Skamp, 2015, p. 314). The lack of consensus surrounding the pedagogy of materials topic can make the task of planning all the more challenging for teachers. However, I suggest that an inferentialist interpretation of concept-meaning in our thought and talk further illuminates specific dimensions of science classroom discourse and pedagogic practice. In illustrating such an approach below, I argue it offers innovative insights into primary science teachers' approach to planning and teaching science lessons. To better illustrate this inferentialist perspective and approach to responding to this pedagogic challenge, I present a short classroom dialogue discussing the classification of ‘sand’ as solid, liquid or gas. However, before I discuss the challenges of classification, I first turn to introduce and review Brandom’s inferentialist theory of concepts.

5.2 Brandom’s Inferentialist Theory of Concepts

Understanding an inferential interpretation of science concepts in teaching contexts is not a straightforward matter. Therefore, I focus first on providing some orientation to how inferentialism as a semantic theory view concepts and meaning (conceptual content) as ‘proposition-like’ before considering a classroom dialogue.

Inferentialism considers the meaning of a term, word or concept, such as ‘solid’, ‘material’, ‘property’, ‘hard’, ‘soft’ etc., as underpinned by an entire web of interrelated claims or statements. This propositional network consists of relations between statements or claims, which are compatible or incompatible; they are logical relations (inferences), where this network constitutes a *logical or inferential space of reasons*. As Brandom states about the nature of language:

> The semantic and epistemic dimensions of thought and language use are not only understood as inextricably intertwined, their common structure is the *inferential* articulation characteristic of the space of reasons. In this picture, <u>justification</u> (and so its cousins <u>reason</u> and <u>inference</u>) is not only a key concept in epistemological investigations of the nature of *knowledge*, but also and equally a key concept in semantic investigations of the nature of *meaning* (2009, p. 5, emphasis in original).

For Brandom, concepts are not located in minds 'between the ears of the individual' (2011, p. 4) nor within language, but are understood as concerning our reasoning, as concept-using creatures, i.e., our thought and talk. Brandom refers to our concept-using practices as a distinctive game we humans play, a *game of giving and asking for reasons* (GoGAR). The core practices in playing this game are inference and assertion (Brandom, 2001, p. 15). In our discursive practices, we make *assertions* which express our rational judgments. Our thought and talk are not made in isolation but always already stand in relation to other claims and inferences; these are *inferential relations* or *commitments*. In our assertings and doings, these inferential relations constitute an inferential articulation in what we say and do. In positing his theory of concepts and meaning in our discursive practices, Brandom claims:

> The master idea that animates and orients this enterprise is that what distinguishes specifically *discursive* practices from the doings of non-concept-using creatures is their *inferential* articulation. To talk about concepts is to talk about roles in reasoning. (2000, pp. 10-11)

Inferentialism approaches the analysis of meaning or semantics (i.e., conceptual content) not in terms of *reference* but in terms of *inference* (Bransen, 2002). In coming to understand claims and what they mean, inferentialism shifts the explanatory focus from referential relations between statements and external state of affairs to the inferential relations between statements and other statements. As discussed above and in the previous chapter, these inferential relations are formed through our linguistic and social practices, that is, discursive practices, which Brandom refers to as a game of giving and asking for reasons. His focus on the inferential relations between claims, positions his view of semantics in resolutely holist terms, expressed as 'one cannot have *any* concept unless one has *many* concepts' (Brandom, 2001, p.15). To better understand Brandom's philosophical ideas and their implications for concepts, meaning and conceptual understanding in science classrooms, I sketch out the central concepts essential to his inferential semantics: commitments, entitlements and incompatibility relations. These concepts constitute the core of his inferential semantics and serve as the 'building blocks of meaning' (Bransen, 2002, p. 374).

Commitments

According to Brandom, 'commitments' underpin our use of any concepts. What we are committing to is the particular inferential relations between concepts that determine the meaning of the concepts we are using. For example, in saying or thinking something is a 'table' means we are asserting that it is a table. In making such an assertion, according to Brandom, one undertakes a number of inferential commitments, that is a commitment to other claims as related to the initial assertion, and determines its meaning. These commitments could be that the table has legs, a flat surface, it has chairs around it, you can place things on it, or you can dine around it and so on. These inferential relations give the term 'table' its meaning. They expose what claims follow from the application of the concept 'table' and what claims it follows from. Claiming something is a table, serves as giving a reason for why you sit around it or why you do not sleep on it. Conversely, saying it you sit around it and put cutlery on it is giving a reason for saying it is a table. In sum, for Brandom, 'commitments' refer to the normative and social dimensions of language use, i.e., the rules or norms that govern the application of particular concepts (an object is not called a table if it has a vertical plane rising from the horizontal plane, i.e., it has a back and is a chair). This captures the ways in which our linguistic practices involve implicit agreements and shared understandings in the formation of concept meaning.

Let me take an example from biological classification here, say of a spider. A child seeing a spider on her desk may assert, 'Ah! There's an insect.'. The child, on seeing a spider and knowing it to be a spider, may be committed to 'it has legs', 'it has body parts', 'it crawls'. So, whenever the child sees a spider, she is reliably disposed to repeat her commitment to it 'having legs', 'having body parts', 'crawling' and 'being an insect'. Such commitments underpin her moves, beliefs and assertions. She may acknowledge that spiders have several legs but may not have undertaken all of the commitments that govern the correct use of the concept 'spider' i.e., that it has 'eight legs', 'two body parts' and is 'not an insect'. However, once in the science classroom, things are different. Here the priority is given to the technical and specific language of science as opposed to everyday language, thought and talk. This classroom context immediately subjects students to a different standard of assessment and requires students to refine their use of concepts and meanings that are compatible with scientific knowledge of school science.

In thought and talk within the knowledge domain of science, the use of the term 'spider' does not just involve a commitment to it 'having legs' or 'crawling' but requires a commitment to it 'having eight legs', 'two body parts', 'laying eggs' and 'is an arachnid' and 'is not an insect'. Although not all of these commitments may be necessarily relevant to primary science, these inferential relations are nevertheless present and govern the discourse, concept use and the meaning of concepts. In this particular instance, the term and concept 'spider' involves an inferential commitment to it being an 'arachnid' but also 'not an insect'. In other words, in order to be doing science (i.e., playing the game of giving and asking for reasons in science) there needs to be appropriate commitments to inferential relations that govern the correct use of the term 'spider'. Whatever 'is a spider' necessitates it being 'an arachnid'. Such inferential commitments, underpin the correct application of a concept, which holds within science classrooms regardless of whether or not the student acknowledges or undertakes a commitment to 'A spider is an arachnid'.

Inferential commitments are rules that govern the moves players make in playing the game of giving and asking for reasons. Such relations or inferences are not simply of one's own choosing but are normatively determined. Put differently, whether or not a speaker or player acknowledges all spiders are classed as arachnids in the knowledge domain of science, those relations still hold or are preserved as norms governing science discourse in science classroom talk. This segues into Brandom's second fundamental concept, the role of *entitlements*.

Entitlements

Entitlements follow from the particular commitments made. Depending on which commitments are involved in applying a concept, only certain entitlements to its application may follow. It is helpful to provide the example of Boche given by Brandom in full here:

> If one thinks of a pejorative expression which joins descriptive circumstances of application to evaluative consequences of application, the World War I epithet, Boche, has circumstances of application that someone is of German nationality and consequences of application that they're barbarous and more prone to cruelty to other Europeans. …But if you don't want to endorse the inference from the circumstances to the consequences of application, all you can do is refuse to use the word because you don't endorse the inference that's curled up in it. You can't say that there are no Boche or that the Boche are not so bad. That's denying that the circumstances of application apply. …[W]hat inferences are you then committed to? When they're made explicit, do you really want to endorse them? Somebody who's worrying about inference is going to look at the concept Boche and say, "Well, the inference is from German nationality to barbarity and cruelty, but what about Goethe and Bach?" Having made that inference explicit, now you're in a position to be critical about it. (Williams and Brandom, 2013, pp. 379-380)

The point Brandom makes in this example is that once you are aware of the implications of what you have committed to, in applying a concept, you can see what you are entitled to as a result of your commitments. You can be made aware that what you took to be the correct meaning of a concept (based on your original commitments) no longer works as you intended. This is precisely what teachers do when they successfully help a student learn to develop the correct meaning of a concept. In this context, inferential semantics alerts us to the importance of a teacher's competence in engaging with students through the giving and asking for reasons. The teacher's role is to assist students in acknowledging their commitments and acquiring new entitlements. The teacher requires an inferential orientation (Derry, 2013b) to the knowledge domain, which provides her with the necessary flexibility to engage with students in a meaningful manner. This enables the teacher to actively participate in the game of giving and asking for reasons, fostering an environment where students can thrive and develop their understanding.

Incompatibility Relations

I have addressed two fundamental components of Brandom's inferential semantics: commitments and entitlements. There is a further third fundamental technical term, which completes the triangulation of the inferential role concepts play in our reasoning in giving and asking for reasons: *incompatibility relations*. In Brandom's account of inferential semantics, incompatibility relations refer to the logical connection between different statements or propositions that cannot coexist coherently. These compatibility and incompatibility relations determine the logical constraints on what claims and inferential connections can be included or precluded within discursive practices. Together, commitments, entitlements and incompatibility relations, serve to establish the logical structure of linguistic and social practices. To return to our earlier example, when one asserts, in the context of the science classroom, 'Spider is an insect' and thus commits to norms governing this use, an incompatibility relation arises. However, in the classroom how this incompatibility relation is handled is different to the way it would be if we were applying Brandom's argument in a strictly logical way. This is because in a classroom the development of a learner's meaning-making is part of the development of their learning. As a result, teachers are particularly interested in alerting them to the entitlements that follow or fail to follow, from their particular commitments.

While these logical relations of incompatibility may seem like a rather demanding constraints on classroom talk and teachers, these rules and norms are not something we are consciously or explicitly aware of, unless made so. Nevertheless, they are always in play in discursive practices. The aim of introducing and employing this inferentialist vocabulary, is to offer a way to make explicit and to enable talk about these implicit dimensions of thought and talk. It is a meta-vocabulary that illuminates the nature and structure of concepts and meaning in our thought and talk, without falling into the representationalist language that approaches concept-meaning primarily in terms of reference. There is no view from nowhere. Inferential relations are always perspectival and relative to the players and the rules in playing the game of giving and asking for reasons. The science classroom offers a useful illustration of how the teacher and pupils are involved, participating in classroom talk governed by the norms of scientific discourse.

Inferential Role Semantics: A Summary

These three semantic relations (i.e., commitments, entitlements, and incompatibilities) are fundamental to Brandom's account of concept-meaning. The logical interrelations between these three aspects of our discursive practices form an inferential network. They provide a distinctive vocabulary that makes explicit the logical structure or systematicity of a concept and its *inferential role* in our thought and talk as concept-using practices. Brandom's inferential semantics allows us to spotlight how possessing scientific 'facts' or appropriate scientific vocabulary remains insufficient for effective science teaching. Inferentialism offers a vocabulary that accounts for the differences between teachers and pupils in thought and talk. In doing so, the inferentialist vocabulary addresses the perspectival nature of concept-use, while allowing for shared and diverse meanings of scientific concepts appropriate to classroom talk. The expert teacher would be aware of a wide range of inferential relations that constitute particular facts in scientific discourse. She would be responsive not only to the term 'spider' and its classification, but the various presuppositions that underpin children's thought and talk of the term, such as 'having legs' or 'having body parts'. The systematicity of disciplinary knowledge, and a practical mastery of applying concepts in justifying claims, allows the teacher to be responsive to what follows from what and why. This allows her to engage with her pupils' thought and talk (commitments and entitlements) with more coherent, robust and persuasive moves. With the logical structure and semantic meta-vocabulary of Brandom's inferential theory of concepts in view, I turn to illustrate how this inferential semantic view of concepts informs a classroom scenario in classifying sand in the context of a teacher-pupil dialogue.

5.3 Classification of Sand: An Inferentialist Analysis

I begin this section by presenting a short classroom dialogue on classifying sand, introducing a less clear-cut and problematic scenario in discussing materials. I present an illustrative dialogue, fictitious in nature but inspired by classroom observations and theoretical discussions[54]. The teacher (Ms Kapoor) introduces the

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[54] I have drawn on various literature in developing my understanding of materials and classroom talk. However, classroom dialogue reported in the literature are often very short extracts. Rutledge refers to materials as one of 'tricky bits' of the primary science curriculum (2010). While my classroom data also did not provide an extended dialogue, in order to exemplify the inferentialist point, I drew on my data illustratively presented as fictitious as shaped and inspired by various conversations and readings related to primary science teaching and learning relating to materials and more specifically solids, liquids and gases classification framework.

material sand, which opens up the classification activity and discussion with pupils. In leading the class in thinking about sand and where they would place it within the Venn diagram, she asks pupils whether it is a solid, liquid or gas?. One child (Ashvin) responds, claiming 'sand is a solid'. This short communicative exchange illustrates the *inferential role* of the concept 'solid' in discussing materials in the science classroom.

Dialogue on Classification of Materials[55]: Is sand a solid or a liquid?

Teacher: *Let's start with sand. Is sand a solid, liquid or a gas? Ashvin!*

Ashvin: *Sand is a solid.*

Teacher: *Ok, Ashvin thinks it's a solid. Can you try and tell us why you think it's a solid?*

Ashvin: *Well…it's a solid…because it's hard…it's got hard grainy bits in it.*

Teacher: *So, Ashwin says it's got hard grainy bits. Is that what makes sand solid?*

Ashvin: *Yeh!*

Teacher: *Right, so, let's just think about this. Ashvin says sand is hard and this makes it a solid. So, if something is not hard, would it be a solid? Let's take something that is not hard, take this sponge, is it hard?*

Ashvin: *No.*

Teacher: *Ok, so what do we think it is? Is it a solid? Or is it a liquid?*

Ashvin: *Yeh, sponge is a solid and clothes are soft and they're solid. Solids don't have to be hard.*

Teacher: *So, if solids don't have to be hard and soft things can also be solids, now thinking about sand, is being hard, enough to make it a solid?*

Ashvin: *Well, it's also got a shape.*

[55] This dialogue involves a single pupil. Classroom dialogue in reality involves multiple pupils. I limited participants at this stage to keep the interaction simple for illustrative purposes. An inferential analysis of classroom dialogue and interactions is the focus of Chapter Six and discussed in Chapter Seven.

Teacher: *Ok, so what shape would you say sand is?*

Ashvin: *It's got…the grains are kind of like round, they have different shapes, but their shape doesn't change.*

Teacher: *So, do all solid things need a shape? We agreed things don't have to be hard to be a solid, but does it have to have shape to be a solid?*

Ashvin: *Tables and chairs have shape…I think all solid things have a shape. They can be different, but they don't change their shape.*

Teacher: *Ok, what if it can change its shape, is it then a solid or a liquid?*

Ashvin: *Well, you can change the shape of paper when you cut it, but it doesn't change its shape on its own. Liquids…they change when you pour them into a cup…like water changes its shape. Solid won't, you have to do something to it.*

5.3.1 Classifying Sand: Inferential Articulation of the Concept 'Solid'

The following is an inferentialist analysis of the meaning of science concepts in primary classrooms in thinking and talking about classifying sand. In asking a question and initiating the dialogue, the teacher primarily engages with uncovering children's thinking and understanding (justificatory and critical reasons) for what makes sand a solid. Although this dialogue is a short extract from what would otherwise be an extended classroom discussion, as I attend to the inferential role of the concept 'solid', I delimit my focus on both the pupil's and teacher's perspective in addressing three different points of analysis, namely: Ashvin's Initial Conception, his Revised Conception and the Teacher's Perspective.

Ashvin's Concept of 'Solid'

Ashvin articulates his initial understanding of 'solid' in asserting that **'sand is a solid'.** Inferential semantics consider concepts as a set of propositions and their articulation as a network of compatible and incompatible logical relations[56] between propositions. In the above dialogue, the commitments Ashvin asserts from turns 1 to 6 have been tabulated below. Ashvin's assertions are identified by single quote marks ('Sand is hard'). Capitalised propositions (e.g., Sand is a liquid) represent possible implicit commitments I have selected:

Ashvin's Initial Conception

Inferential Commitment: 1. 'Sand is a solid'	
Logical Compatibilities	Logical Incompatibilities
'sand is hard'	Sand is a liquid
'sand has hard grainy bits'	
Solids are hard	
Sand grains have shape	
Solid things have shape	

Table 4. Ashvin's Initial Conception

In articulating his concept of 'solid', Ashvin publicly acknowledges his *assertional commitments*, made available for assessment by others. While he undertakes other commitments, these are not expressed in classroom talk. Any concept is a vast and complex *inferential network*. The diagram (Fig. 7. below) illustrates Ashvin's inferential articulation of the concept 'solid' from turns 1-6 of the dialogue. Such fixed visual representations of inferential relations are not really fit for purpose. They fail to capture the dynamic and perspectival nature of concepts, which an inferentialist vocabulary highlights (i.e., relative to the player). The inferential relations are constantly changing, being updated by player/interlocutors at every stage of

[56] According to Brandom, such inferences are not formal logical or syllogistic ones but logical compatibility and incompatibility consequential relations. It is not the case that, if A and B then C, but A & B therefore, C, there is no logical entailment.

discourse (relative to the game)[57]. Nevertheless, I offer these representations as an entry point, if only to exemplify how representations serve as a poor medium in capturing the richness, complexity and dynamic nature of such an inferential network of propositional relations expressed in thought and talk.

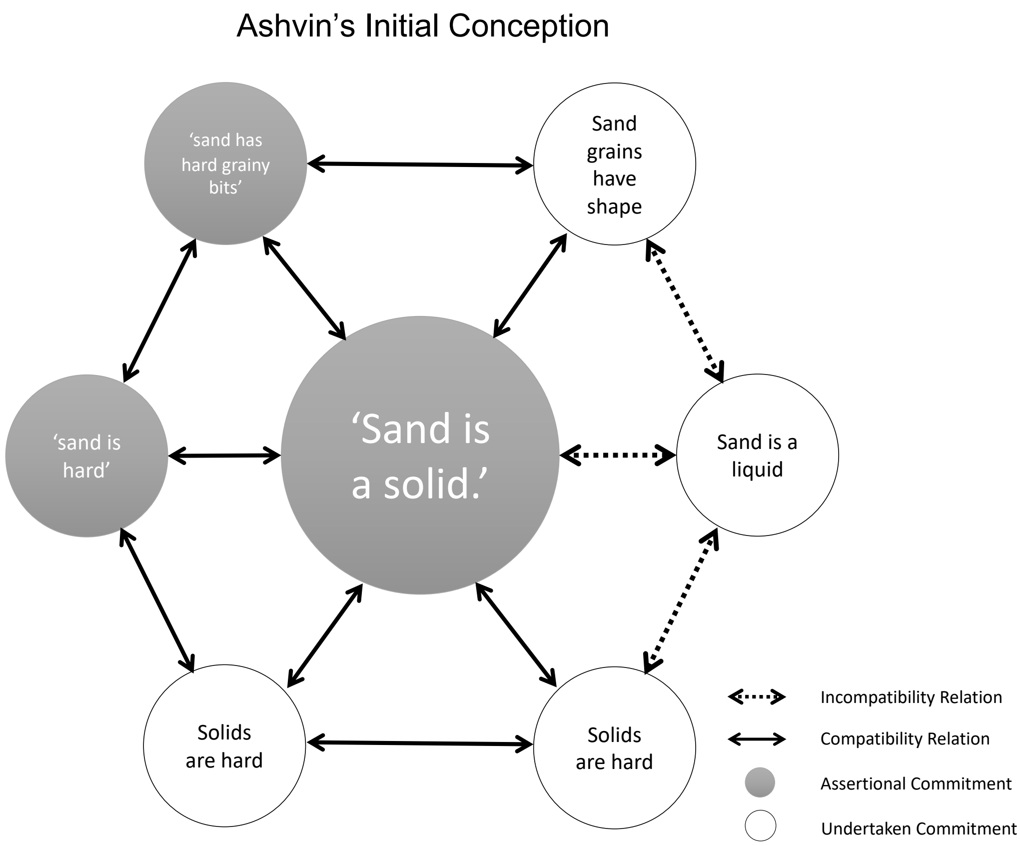

Fig. 7. Ashvin's initial conception

An inferentially-oriented/expert teacher is acutely aware that, what Ashvin means in asserting 'sand is a solid' and using the term 'solid', may differ from her own scientific understanding. Since Ashvin's *assertion* is connected to a constellation of other ideas he is committed to, the teacher's initial move is to simply ask Ashvin *why*

[57] This pre-empts the next chapter that addresses how this inferential semantics and concepts play out in discursive practices captured by Brandom's scorekeeping analysis or model. I discuss his approach to analysing discursive practices in view of Brandom's semantics presented here, which he claims must answer to pragmatics, which for Brandom is to be understood as normative pragmatics.

he thinks it is a solid. In unpicking his thinking, the teacher forces Ashvin to justify his claim to gain an entitlement[58].

Ashvin's Articulated Conception

An expert teacher recognises Ashvin's conclusion **'sand is a solid'**, as expressing specific compatibilities with other claims, like **'solids have shape'**, **'sand has hard grainy bits**', while remaining incompatible with others, **'sand is liquid'** or **'liquids can be poured'**. Ashvin articulates *his* reasons, justifying his conclusion '**sand is a solid'**, as the dialogue proceeds, subsequently articulating his inferential commitments, **'sand is hard'**, **'sand has shape', 'solids don't have to be hard'.** Now, Ashwin may not acknowledge such commitments in a formal sense; nevertheless, they remain acknowledged within classroom talk, as moves in playing the game of giving and asking for reasons. In publicly acknowledging his commitments and inferences, he opens them to challenge by others. I attempt to illustrate the development of dialogue and revisions to Ashwin's initial inferential network of claims. In every move in the dialogue, Ashvin updates his commitments and thus his conception of 'solid', which continues in the dialogue from turns 6-18 (see fig 4). These updated inferential relations constitute Ashvin's conception of solid. Since Ashvin freely makes these judgments, changing and updating them as the dialogue proceeds, the diagram below is not necessarily a direct reflection of Ashvin's own constellation of commitments and entitlements[59]; its use is illustrative.

[58] A key inferentialist point is that Ashvin's assertion 'sand is a solid', is not a deductive inference. For Brandom, Ashvin's inference does not reduce to a syllogism of the form "If A and B, then C". It could well be the case that A or B may not be taken to be the case and that C may still be inferred. Statements or propositions are not considered absolute but subject to conditions. For example, a possible implicit commitment 'solids are hard', requires the teacher to think through whether all solids are in fact hard, which leads to talk of soft materials like sponges.

[59] It is what Brandom refers to as a player's normative attitude or a deontic score in playing the game. However, this account is developed in his deontic scorekeeping model that I develop in the next chapter

Ashvin's Articulation of 'Solid'[60]

Inferential Commitment: 1. 'Sand is a solid'	
Logical Compatibilities	Logical Incompatibilities
1. 'sand is hard'	3. Solid things are hard
2. 'sand has hard grainy bits'	4. All solids are hard[61]
5. 'sponge is a solid'	
6. 'soft things can be solids'	
7. 'solids don't have to be hard'	
8. 'all solid things have shape'	
9. 'sand grains have shape'	
10. 'solids don't change own shape'	
11. Liquids can be poured	15. Solids cannot be poured
12. Liquids change shape on its own	
13. 'Liquids flow and changes its shape'	
14. Solids have a stable shape	
16. 'solids only change shape if you do something to it'	
17. Sand can be poured	18. Sand is a liquid

Table 5. Ashvin's Articulation of the concept 'Solid'

(Chapter Six) in relation to dialogue and communication and concept-use in discursive practice. I delimit myself here to an inferential semantic account of concept meaning within a knowledge domain.

[60] I focus on claims and their relation to the concluding assertion or inferential commitment (1) 'Sand is a solid' to keep the illustration simple and refrain from attending to interrelations between claims, which nevertheless remain present.

[61] These are claims that I portray Ashvin as having committed to but not articulated. These claims constitute his presuppositions.

Ashvin's Revised Conception[62]

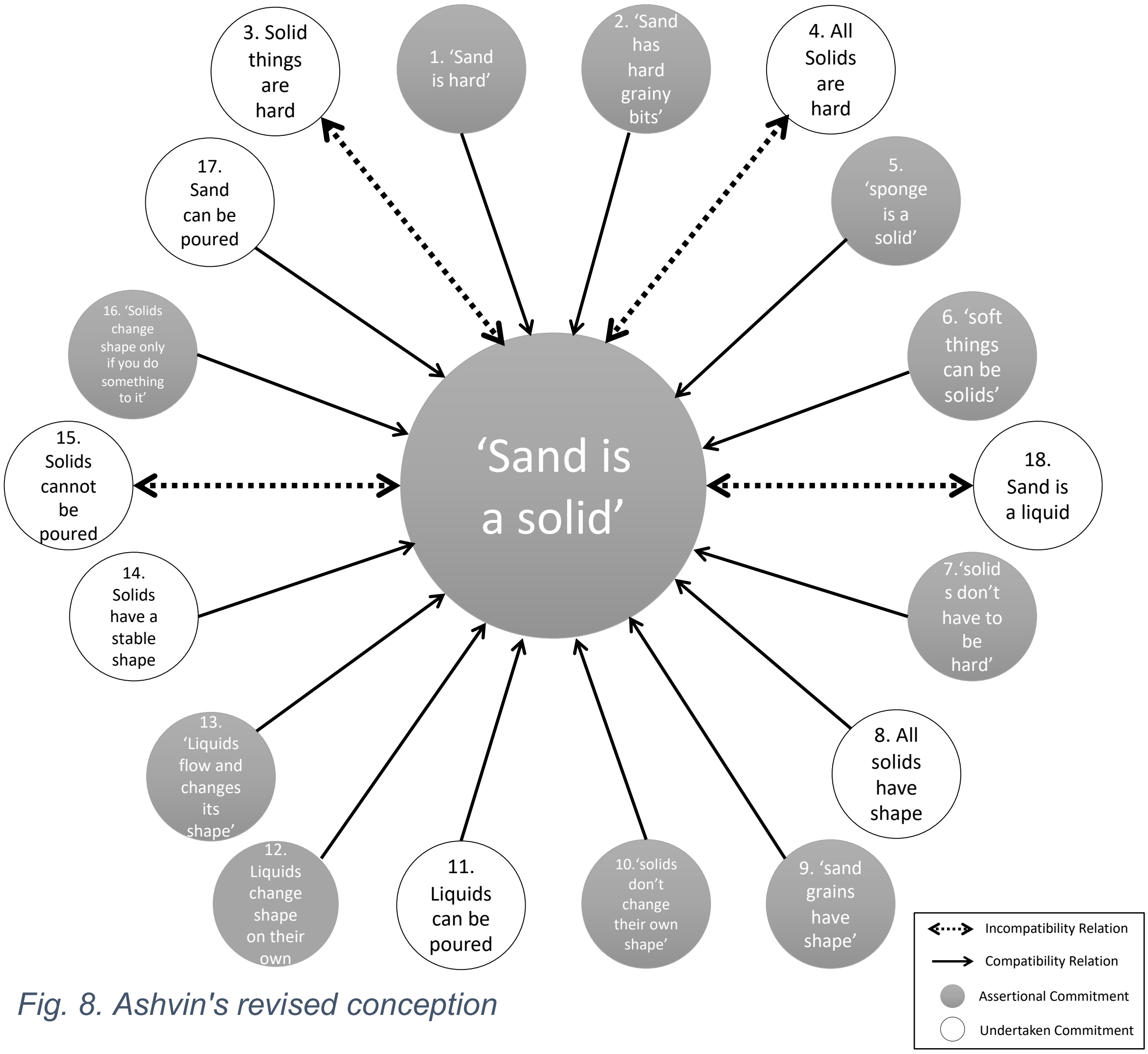

Fig. 8. Ashvin's revised conception

From turns 1-6, Ashvin asserts two commitments, while in turns 6-18, Ashvin asserts ten additional commitments in articulating his own inferential reasoning and use of the concept solid. What is at stake here is not a state of mutual exclusivity but a dynamic process of updating logical or inferential relations. Thus, is not setting up of

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[62] Where Ashvin has made an assertion and hence a commitment, these have been represented by a grey bubble. There are innumerable implicit commitments of which a limited set has been presented here as clear bubbles. I have presented 18 propositions here modelled on the above dialogue. As such, I delimit my diagram to illustrate their relation to the inferences 'sand is a solid', thus there are 18 such relations presented by arrows. The arrows are either solid lines or dashed. Whether propositional claims are asserted (assertional commitment) or implicit (undertaken commitments), they all occupy a relation to the inference 'Sand is a sold' (inferential commitment). These relations are logically compatible represented by a solid arrow or incompatible indicated by a dashed arrow.

binary relations but the perspectival nature of our conceptions as always in flux yet, governed by norms, the logical relation or inferential rules of the domain knowledge. A significant development is the presence of four incompatibilities, whereas there was just one before. In thinking about various objects, he begins to update his commitments about what can and cannot be done to different materials. The introduction of the sponge challenges Ashvin's justification which solely appeals to his commitment to being hard. A critical update in his thinking is acknowledging 'solids don't have to be hard'. The classroom thought and talk, subsequently turned to discussing and exploring ideas about shape and stability.

Ashvin: *Well, I can cut paper, but then I'm cutting the paper it's not the paper changing its own shape. When you pour or put water on a table it will move around and it'll change its shape. If you take a liquid out of a container, it will flow and changes its shape, but a solid won't, you have to do something to it.*

In thinking about the concept 'shape' as related to 'liquids', Ashvin maintains you can 'pour water' and that its 'shape changes'; he further relates this to ideas of 'flow' and instability of the shape of liquids. This sits in contrast to solids as having 'its own shape', changing only if you 'do something to it'. The expert teacher may well be aware that scientific concepts are constantly being updated by pupils[63]. However, the inferential nature of Ashvin's concept of solid, is not some fixed, stable entity 'between the ears' nor merely a matter of circumstances of language-use. The inferential role of the concept solid articulated in Ashvin's thought and talk is dynamic and in constant flux at every stage of the dialogue[64]. A crucial inferential point here is

[63] The child/Ashvin as a player of the game in making moves is simultaneously making and changing or updating his commitments and entitlements. A more detailed account of this process is discussed in relation to Brandom's scorekeeping model of discursive practices. For now, I remain focussed on concepts, meaning and his inferential role semantics of concepts in classroom communication.

[64] This dialogue from an inferentialist perspective is considered a game of giving and asking for reasons involving both reasoning and discourse, or thought and talk as two sides of one coin, inseparably intertwined.

acknowledging the role perspective, not just in Mortimer and Scott's sense of a scientific point of view, but the players' perspective and their inferential articulation of a concept. The inferentially-oriented teacher's *responsiveness to reasons* that her pupils articulate allows her to assess the correctnesses and incorrectnesses of their constellation of commitments and entitlements, as ongoing moves within the game, in classroom thought and talk, governed by the norms of the scientific knowledge domain (i.e., inferential rules). Ashvin's thinking about sand and understanding of materials is yet to be articulated in this interaction. However, the teacher's understanding and assessment not only of what is said but what is meant by pupils are crucial to moving this exchange forward in developing children's scientific concepts and understanding of materials. The inferentialist semantic view explains the nature of conceptual content (meaning) and concept use, not only acknowledging the diversity of concept meanings but by further illuminating it as perspectival and dynamic. Brandom provides the logical relational vocabulary that draws on the human work undertaken, the inferential dimension in applying concepts within norm-governed discursive practices. Although the analytic implications of this theoretical reorientation may not be immediately apparent, I focus on developing these ideas in addressing the analysis of classroom discourse in the next chapter.

5.3.2 Teacher's Conception and Scientific Knowledge of Materials

From the teacher's perspective, i.e., a scientific perspective, she is able to recognise how Ashvin's justification that 'sand is hard' (assertional commitment) falls short of entailing or justifying his conclusion 'sand is a solid'. She already understands that not all solids are necessarily 'hard' in an everyday sense of not being hollow (Allen, 2010). Furthermore, although she does not make this explicit in dialogue with her class yet, she still appreciates the scientific concept of 'hard' as a mechanical property of materials and an empirical measure of surface resistance to scratching or material resistance to indentation (Wenham, 2005). The science teacher is aware of the systematicity of scientific terms or the logical relations that constrain the correctnesses of applying concepts (i.e., practical mastery). She already understands that the use or application of the concept 'solid' is not only limited to a set of sensory descriptions such as being 'hard', 'dry' or able 'to flow', which a child may attribute to objects such as plastic cubes, spoons or sand. Such thought and talk would not display the systematic relations articulated in using science concepts in appropriate ways. It is the systematicity underpinning the role concepts play in thought and talk, that animates her interactions. Although the teacher remains committed to Ashvin's original assertion, she may not fully endorse the related claims made by the child. Her inferential orientation to the knowledge domain, the network of propositions and logical, systematic relations enables her to recognise and assess various ways this assertion may be endorsed or challenged. As such, she appreciates that although a claim may be endorsed within scientific discourse, there may be grounds for a challenge in relation to other claims. The diagram and summary of logical relations below present an example of the teacher's inferentially related claims for comparison (Fig.9).

Teacher’s Inferential Orientation to Ashvin’s Claims: A Scientific Perspective

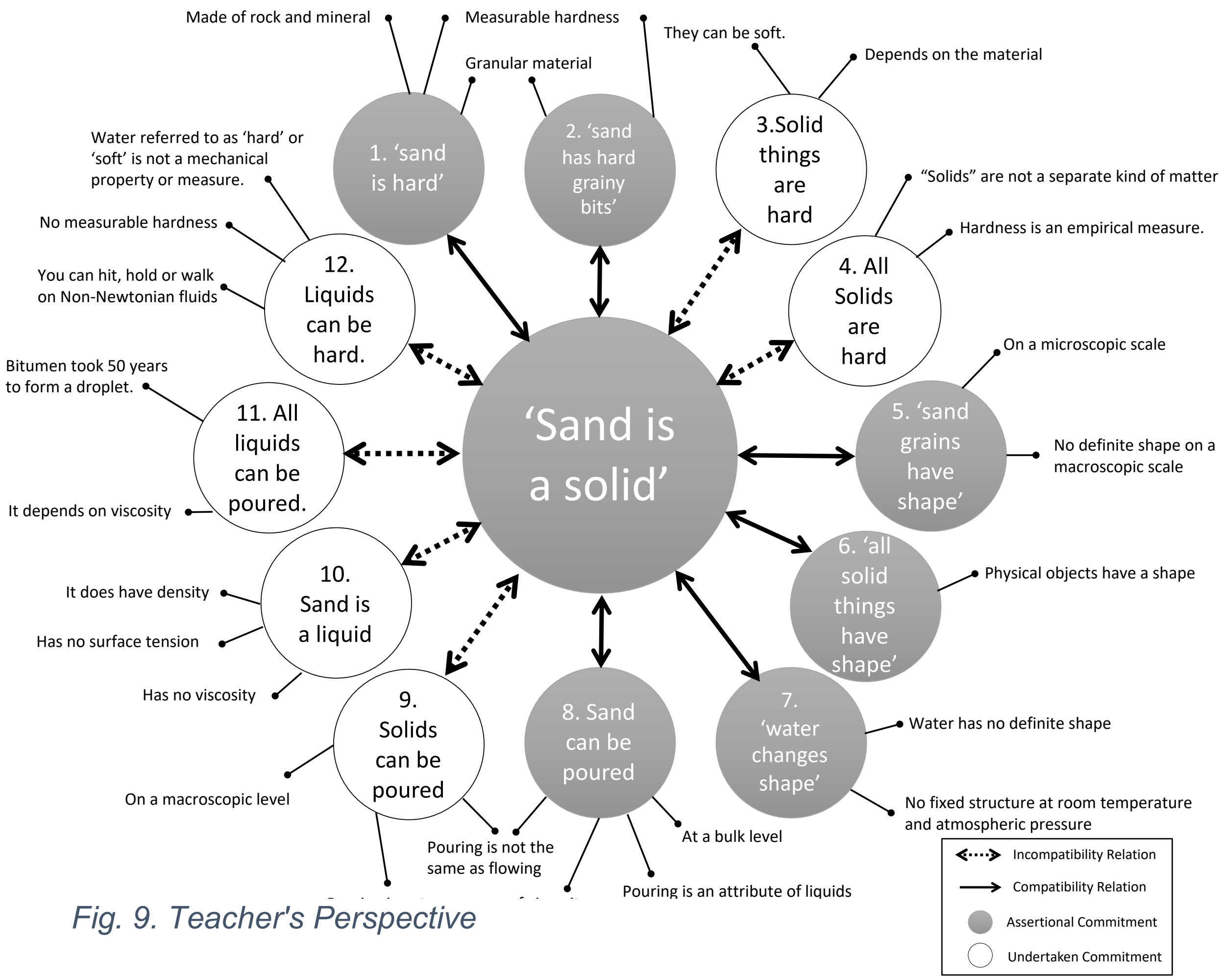

Fig. 9. Teacher's Perspective

The above diagram[65] does not do justice to the vast network of the teacher’s inferential orientation to the concept ‘solid’ and related material concepts. It merely illustrates how the meaning of any science concept is perspectival in relation to the presuppositions of the interlocutor. However, within the game concept-meaning or science concepts are constituted by a set of logical inferences which plays a systematic and recursive role in reasoning about materials, i.e., the inferential role of a concept in the knowledge domain of science. The relations are from the teacher’s

[65] My focus here is on the claims made in articulating the concept solid. An analysis of the dialogue and intersubjective communication are to be addressed in the next chapter and developed in relation to the present issue in Chapter Seven.

perspective in relation to the norms of the primary science of materials that govern the game and assessment of the moves made by Ashvin. For example, commitments three and four are assertions the teacher attributes to Ashvin as incompatible with the claim ‘Sand is a solid’ would require assessment and further discussion. Through classroom talk, pupils’ inferential relations are constantly updated and revised at every move in the game. In discussing this process in the next chapter, I develop Brandom’s inferential semantics in relation to his normative pragmatics of communication.

Teacher’s Inferential Orientation: A School Science Perspective

Inferential Commitment: 1. ‘Sand is a solid’	
Compatibility Relations to (1)	Incompatibility Relations to (1)
1. ‘sand is hard’	3. Solid things are hard
2. ‘sand has hard grainy bits’	4. All solids are hard
5. ‘sand grains have shape’	
6. ‘all solids things have shape’	
7. ‘water changes its shape’	
8. Sand can be poured	9. Solids cannot be poured
	10. Sand is a liquid
	11. All liquids can be poured
	12. Liquids can be hard

Table 6. Teacher's inferential orientation to the concept 'Solid'

The teacher may endorse some of Ashvin’s assertions while challenging others in thinking and talking about sand. Given her understanding of granular materials, e.g., sand, she may have good (scientific) reasons for endorsing specific assertions like **'sand is hard'** and **'sand grains have shape'**, while withholding others like **'sand does not flow'**. She understands that solid and liquid properties are not mutually exclusive terms but determined by claims, presuppositions and inferences. Although her own claims may well be compatible with Ashvin's assertions, they follow from a different orientation to claims and their inferential relations, as illustrated above and discussed below. So, while Ashvin's classification may display an understanding that Sand has some solid and some liquid properties, it is the reasons and their role in justifying claims in thought talk that inferentialist semantics brings to the fore.

'Sand is hard': For the teacher, 'Sand is solid' does not simply follow from 'sand is hard' in the everyday sense of it not being hollow[66]. From a scientific perspective, the concept of 'hardness' is an empirical measure of how resistant materials are to pressure or mechanical abrasion, expressed in lay terms as scratching[67]. Moh's scale is the most common empirical test for hardness (Wenham, 2005). She is aware that sand has a variety of forms and uses. Sandpaper, for example, provides a practical spectrum from coarse to refined grains, where silica sand measures high on Moh's scale of hardness. These presuppositions underwrite her claims and challenges regarding sand, hardness or solidity.

'Sand grains have shape': Sand is a granular material. Granular material is 'extremely ubiquitous'[68], second only to water as the most handled material type in

[66] On a microscopic scale, sand grains may be porous or hollow to a certain degree.
[67] Hardness may be measured in three ways, mechanical indention, abrasion or rebound. There are three types of hardness. In primary it is susceptibility to scratching that is emphasised.
[68] The issue is not only cutting-edge science, but spans a number of interesting case studies from the food industry, pharmaceutical, soil erosion, landslides and even the Mars rover that remains stuck in the sand.

industrial processes (MIT, 2018). Of significance here is talk about sand differentiated between the microscopic and macroscopic levels. Although sand grains have perceptual attributes, such as colour, size, shape, and density, these vary for each grain of sand. However, thought and talk about sand is not limited to perceptual attributes. Sand as a material displays various properties, which depend on the scale presupposed in the claims one makes and the subsequent claims that follow from them. A scientific understanding of 'properties' is not limited to perceptual or descriptive aspects but should be empirically quantifiable and measurable. For example, mechanical properties of hardness, strength, elasticity, plasticity, compressibility, or rigidity (Wenham, 2005; Hummel, 2004) are applicable at the granular level, and some remain applicable at the bulk level (e.g., compressibility). The teacher recognises that an assessment of the correctness of applying the concept 'solid' or 'shape' involves commitments to other concepts and claims related to 'object', 'material', 'properties', which draws on several other related concepts regarding 'scale', 'forces', 'motion', and 'direction'. At any point in classroom talk, the teacher or pupil may challenge a particular assertion or conclusion, despite preserving the initial claim or commitment to **'Sand is a solid'**: Take, for example, recent empirical studies of granular materials at MIT that suggest our understanding of the properties of sand, in behaviour and movement, subject to forces, can be demonstrated and modelled as simultaneously solid, liquid and gas (MIT, 2018)[69]. Perhaps more precisely, sand displays the *properties* and *movement* of solids, liquids and gases. Developing empirical models and measures for granular materials not only reveals the nature of sand but of scientific concepts that constantly remain

[69] Although the MIT study is not necessary to explain the properties of sand, it was helpful to illustrate to primary teacher that science education research is not merely theoretical but related to cutting-edge science.

subject to change rather than settled affairs. Alerting classroom researchers and teacher educators to the inferential dimension of the norms governing the domain knowledge and classroom discourse is crucial. It not only supports teachers to developing responsiveness to reasons, building up a sensitivity to the inferential role concepts play in thinking and talking science as a norm-governed affair. An inferentially-oriented teacher, rather than assess correctness by deferring responsibility to scientific facts or authority, appeals to reasons that justify the correctnesses of concept use. The rules of the game (e.g., scientific knowledge domain), rather than restricting the teacher, allow her to acknowledge the ongoing, dynamic process, namely within a (scientific) community, that constantly remains open to challenge and change. This, in turn, allows her to appreciate the perspectival and dynamic nature of children's thought and talk, which remain constrained by the norms of scientific discourse.

Sand does not flow: When Ashvin asserts, 'Sand is solid', he may be committed to the idea or claim that 'sand can be poured' and consequently feel entitled to conclude 'sand can flow'. His idea of 'flow' may be inferentially related to 'anything that can be poured' or 'something takes the shape of its container'. The teacher may call for examples to discuss materials that flow with her class. For Ashvin, 'to flow' is what follows from pouring sand into a cup. For another child, a bedsheet freely moving in the wind constitutes being 'flowy'. Although the teacher appreciates the myriad ways children may understand the idea of 'flow' and other science concepts, her focus is on alerting children to the rules of the game and the use of terms in thinking and talking about the science of materials. In using the concepts 'solid', 'liquid' and 'gas', in assessing and responding to children's assertions, the teacher may not draw all of the above inferences in classroom discussion; nevertheless, such connections and permissible and impermissible moves remain available to the inferentially-oriented teacher. As possible consequences, these inferential moves also constrain practical activities and classroom discourse. Leading her class and inducting her pupils into the normative space of reasons governing what is said, done and believed in the science classroom may involve lesson planning responsively rather than pre-emptively. For example, the teacher, when faced with the concept of 'flow' by pupils, in unpacking, and exploring their ideas, may respond by investigating this concept further to introduce the concepts viscosity or runniness. However, 'flow' and 'runny' scientifically oriented serve as an empirical measure in more scientific ways in disambiguating granular materials and liquids.

An inferential semantic view of science concepts and approach to classification involves an appreciation of this inferential network of claims, a complex set of reasons, that constitutes a normative space of consequences and incompatibility relations, which constitutes the rules of concept application, or practical reasoning with a given knowledge domain, in the present case, material sciences. Brandom's semantics is not confined to words or linguistic practices but makes explicit the inferential structure that describes what we concept-using creatures do in discursive practice in becoming responsible for communicating and understanding each other. In this classroom talk, the teacher is responsible for supporting her pupils to resolve the problem of where to classify sand into the Venn diagram, which she has initiated. In thinking about the teacher and learners, the inferentialist claims: 'It is the task of the teacher to support and guide this process while being aware of the individual learning which manifests itself in the situative teacher-student webs of reasons, and without being able to retreat to an external vantage point outside of the social game.' (Noorloos, Taylor, Bakker, Derry, 2014, p. 326). This inferential space of reasons is not only logical but a socio-normative space.

In teaching, she has an inferential awareness of the correct application of science concepts in thought, talk and activities. This is not to suggest the teacher has all these propositions prepared like playing cards (McCrory, 2015). Her responsiveness to the normative space of reasons arms her with an array of counterfactual responses available at her disposal and a significant degree of freedom in dialogue with pupils. This awareness enables her to engage and challenge her pupils' thinking in articulating their ideas and reasons, using seemingly simple concepts in discussions to become more specific, systematic and refined. A critical inferentialist insight is that even with seemingly trivial claims, much more is involved in thought and talk than one may initially assume. An expert teacher's questions not only serve as evaluation or feedback of whether Ashvin is 'right' or wrong' but reflects that she is intent on unpacking her pupils' own thinking, presuppositions and justification. In view of this inferentialist analysis, in the next section, I explore an approach to classification that makes explicit norms governing the classification of 'sand' and reasons justifying 'sand is a solid'.

While my aim here was to introduce the vocabulary of inferential semantics and Brandom's theoretical (re)orientation of concepts and meaning, a key contribution of the above example lies in illustrating how inferential semantics incorporates minds and discursive practices. At the same time the example also serves to initiate a reorientation of communication, which I discuss in detail in the next chapter. For now, I consider some practical insights for the classification of materials.

5.4 Inferentialism and Classification of Materials

At the start of this chapter, I introduced two pedagogic approaches to classification; the first employed discrete boxes and categories, while the second considered continuous categories represented by a Venn diagram (see Fig.10). Below, I discuss how re-interpreting classification as an inferential activity may illuminate a complementary approach. I propose introducing card statements as a supplementary resource. These card resources would serve to modify classification along inferentialist lines. The table below (Table 7.) summarises the two approaches to classification and related resources, with my proposed inferentialist approach presented as a third option.

Classification Activity Reoriented and Inferential Resources

Pedagogic Approach	**Practical Activity**	**Resources**
Discrete Approach	Classification of object/materials within a discrete system	Objects/Materials Discrete Boxes
Discursive Approach	Placing object/materials within a system	Objects/Materials Venn Diagram
Inferential Approach	Classification of statement cards and placing propositions within a conceptual system (a logical space of reasons).	Objects/Materials Venn Diagram Statement Cards

Table 7. Classification Activity and Resources

Inspired by the above inferentialist semantic insights, I propose an inferentially oriented approach to classifying materials and practical resources for classroom use. I continue to draw on the example of sand in demonstrating. As before, the activity follows a sorting activity in selecting an appropriate location to place the material sand within the Venn diagram (see Fig.10.).

Initial Classification of Sand

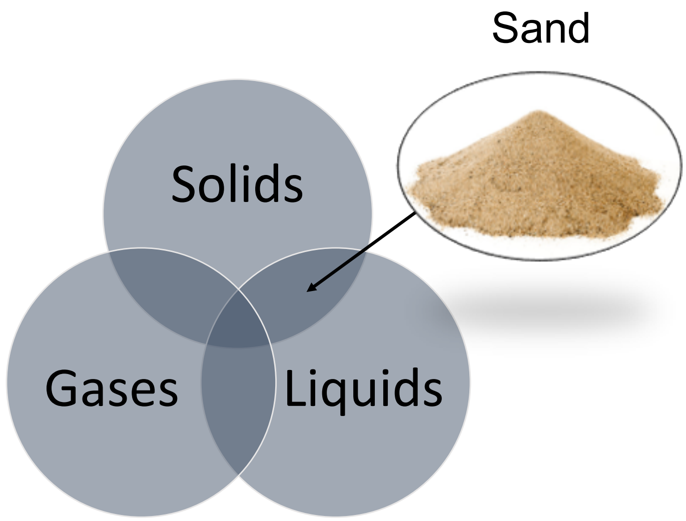

Fig. 10. Initial Classification of sand

Inferential semantics highlight the teacher's responsiveness to reasons in meaning-making interactions in classrooms. The proposed inferential approach foregrounds the role of learners' reasoning and understanding of target concepts by exposing dimensions of concept-meaning and their use in discursive practices that remain obscure or neglected in the sketch of strategies presented above.

5.4.1 Classification: Towards an Inferentialist Approach

Coming to *understand* concepts or classifications as norms involves more than the practical act of appropriately locating objects within some representational space (i.e., the Venn diagram). From an inferentialist perspective, classifications or concepts not only constrain thought, talk and actions. Concepts and classifications are understood as norms, not as fixed rules but as always open to disruption and modification, in the use of science concepts in *conceptually meaningful* ways. For example, take the demotion of Pluto which was a result of disrupting long-held assumptions about the concept 'planet' (see Chapter Nine). Classification, re-interpreted as an inferential activity, involves acknowledging the reasons and inferential relations that animate players' moves. An inferential move not only consists of placing sand in the appropriate location but making appropriate judgements (inferential commitments) in placing claims within the logical space of reasons, which constitutes an inferential move in reasoning. As illustrated above, this inferential reasoning involves acknowledging what commitments and entitlements are in play in thinking not only about sand but solids, liquids and gases. This inferential move is not a separate subsidiary activity. In classifying sand, one is already engaged in practical reasoning, judging how sand relates to the classifications and consequent permissible and impermissible moves in thought, talk and action. Such inferential activities in practical reasoning are articulated by pupils in what they say and do in classification. Thus, the first step in an inferential modification is to introduce a set of propositions as cards that transform this practical activity from an object sort into a card sort exercise. I turn to illustrate how these statement cards as a classroom resource may support an inferentialist approach in the primary classroom.

Classifying Sand and Card Resources

Introduction of Card Statements: I present below a set of cards for sand as an example (see Fig.11). The next step illustrates how pupils may undertake this modified activity. The statements are by no means exhaustive but limited for illustrative purposes[70].

[70] Potentially, these resources, could be made physical or digital involving any number of statements ranging in complexity and materials sets.

Example of Card Statements

Fig. 11. Card Statements for sand

These individual cards are a collection of statements relating to a particular material e.g., sand. The card statements present a range of claims relating to sand, from obvious or everyday claims to more scientific ideas (see Fig.11 above and Fig. 12. below). In addition to the practical classification of sand, card statements make learners' judgments visible. It reveals another dimension of the activity, i.e., inferential moves, which are made available for assessment, challenge or endorsement by others in the classroom.

Set of Card Statements for Sand

1. Sand does not have its own shape.	2. Sand has its own shape.	3. Sand can be physically manipulated.	4. Sand cannot be handled by hand.
5. Sand can flow.	6. Sand does not flow.	7. Sand can be poured.	8. Sand cannot be poured.
9. Sand is stiff or rigid.	10. Sand is not a load-bearing material.	11. Sand is hard.	12. Sand has surface tension.
13. You can put your hand through sand.	14. Sand does not have surface texture.	15. Sand feels wet.	16. Sand is elastic.
17. Sand feels rough.	18. Sand bends easily.	19. Sand is flexible.	20. Sand is practically incompressible.
21. Sand has a fixed volume.	22. You can hit sand.	23. Sand is strong and does not break easily.	24. Sand has mass.
25. Silica sand measures 6-7 on Moh Hardness Scale.	26. Sand has no measurable viscosity.	27. Sand has measurable rigidity.	28. Sand is not fluid.

Fig. 12. Selection of cards for classifying sand

Classification of Card Statements: The next step involves classifying the cards in two parts. The first part consists in sorting the entire set of cards into those deemed compatible or incompatible with learners' initial classification of sand[71]. Once pupils have sorted cards into those ruled in and ruled out in favour of their classification,

[71] This activity could be conducted individually or as a group.

they can move to classify the ruled-in cards. A review and discussion of ruled-out cards would serve to highlight disagreements between pupils that could inform the activity or planning of future lessons[72]. The second part requires pupils to assign a location to each card within the Venn diagram in ways that justify their initial classification of sand (see Fig. 13. below). The practical activity draws into the 'social plane', learners' implicit judgments in classification.

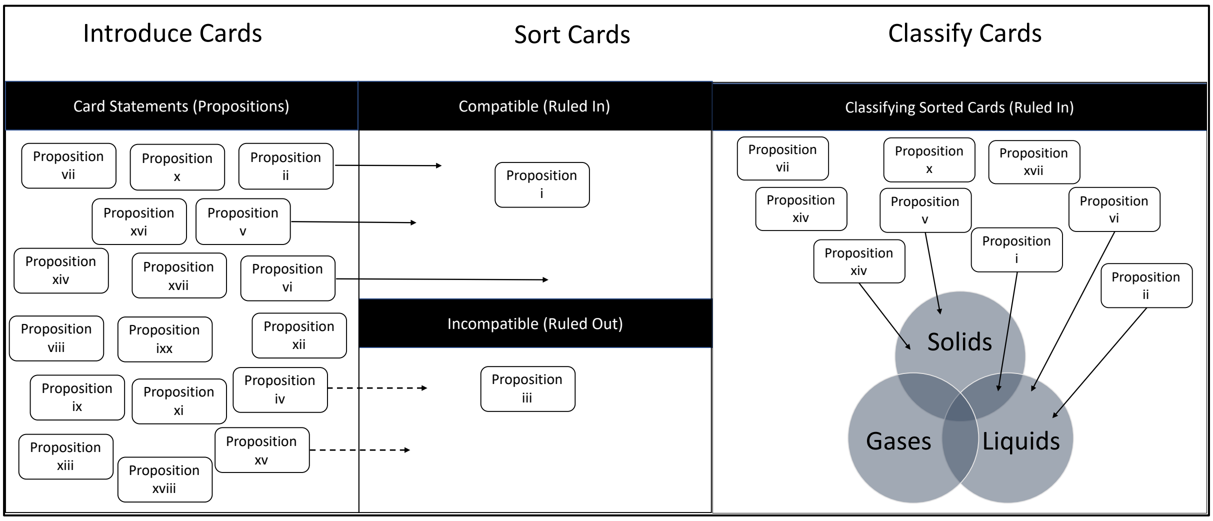

Fig. 13. Inferential classification of sand

Teacher's Inferential Orientation to the Knowledge Domain

The expert teacher has a rich network of inferential relations and is therefore aware of the correctnesses and incorrectnesses[73] underpinning pupil moves in classifying sand. In classifying the cards, pupils' reasoning remains implicit in their practical moves. However, the cards make visible and comparable differences in pupils' inferential judgments. Thus, the teacher, in discussing their judgments and inferential reasoning, can call on them to justify their moves. In seeking to make explicit their reasons for initiating and animating their moves as inferences, she begins to assess

[72] I have kept the example simple here by focussing on limited statements.
[73] Brandom (2009) uses these terms in recognition that correctness is not an absolute but relational and normative.

not only what they do or say but what they mean. The activity is no longer simply a matter of a right or wrong answer but rather assessing the *correctnesses* and *incorrectnesses* of claims underpinning an inferential move. Let us take, for example, a teacher's justification for classifying sand as a solid, which may yield an answer in the following manner:

> Sand has certain limited properties of liquids but only at a macro scale as a bulk property. Sand is a granular material composed of parts. At this granular scale, viewed from perspective of grainy bits (constituent parts) the material can be subjected to forces and changes that display mechanical properties such as brittleness, roughness, hardness and compressibility, which can be scaled and observed on a bulk level. So, although sand displays certain liquid properties on a bulk/macro level, it lacks certain essential liquid properties such as viscosity. On the whole sand displays more solid properties and few liquid properties limited to large scale.

The teacher's ability to challenge and respond, to give and ask for reasons concerning claims and beliefs pupils articulate, is precisely what constitutes an expert teacher's practical *mastery* of the concepts involved or subject expertise or practical reasoning as opposed to inert scientific facts, 'background information' or 'content knowledge'**.** The teacher's inferential orientation to the knowledge domain, and her responsiveness to norms lies in her ability to conscientiously discern better reasons in assessing and justifying claims in dialogue with the children. It is what is crucial to what an expert teacher does and ought to do in communicating scientific concepts. In this manner, understanding a solid, or classifying sand, is not simply a matter of understanding where it is to be placed within a Venn diagram but being able to place judgments within a systematic, logical space of reasons and to justify or give reasons for why such a move, claim or action is legitimate in playing the game governed by the rules or norms of the knowledge domain of science, which are constantly subject to change over time forming the history of scientific knowledge.

5.4.2 Classification in Teaching and Learning Science: An Inferential Mode

The inferentialist analysis and resources illustrate how easy it is for teachers to underestimate just how much is involved in thinking and understanding a science concept, as it is constituted by an entire constellation of relations to other concepts and claims (logical relations and inferential role). The inferentialist resources are aimed at intervening in teachers' approach to classification, emphasising the appropriate and inappropriate *reasons*, without which the teacher risks slippage into more representational modes in teaching. For example, Mortimer and Scott's analysis of classroom interactions involved *representing* the change and development of communicative patterns across teaching episodes and sequences (see Chapter Three). Their dialogic approach to classroom activities, discourse and meaning-making, argued that practical activities 'cannot speak for themselves' (2003, p. 1). Their communicative approach was an attempt to make visible the classroom talk around the practical activity that made it meaningful. While these representations may be valuable tools for teachers and researchers, the inferentialist argument lies in how these representations of communicative practices do not speak for themselves either. Representations are not themselves self-explanatory[74], but as

[74] This was an issue addressed by Wilfred Sellars and his argument of the Myth of the Given. (See Chapter Four §4.1 for details.)

patterns of relations in thought and talk of science classrooms and activities, they are relations that themselves need explaining. The inferentialist critique of the MMF approach is that making the form or function of meaning-making practices *visible,* by *namings, labellings, referrings* or *classifyings*, such as communicative approaches or patterns of discourse, does not explain the nature of patterns represented nor how they are established in the first place. Speaking to this very issue of the 'relations between representation and what is represented', Derry claims 'the question of how this association arises is a matter of pedagogical importance.' (2013a, p. 143). From an inferentialist perspective, these relations are not explained by being represented as patterns or being named or referred to. Interpreted as inferential relations, these relations are *reasons* that animate what we say, do and believe and serve as reasons for subsequent sayings, doings and believings. Brandom's inferentialist meta-vocabulary offers a non-representational explanatory approach and resources that expose implicit dimensions in our practical activity. An inferential approach not only involves the ability to see patterns but also to determine what they mean by recognising or explicating *inferential patterns* implicit in our reasoning and the normative constraints relative to the games we play.

Brandom's theory of concepts, his inferential semantics, attends to the inferential role of concepts in our reasoning and their use in norm-governed practices. According to Brandom, the development of a word or concept meaning is tied up with its use – an awareness of the correctnesses and incorrectnesses of concept application articulated in thought and talk. Learning or coming to understand a concept is to master the network of inferences that constitutes concept meaning (inferential role) articulated in discursive practices. In developing an inferential awareness of the permissible and impermissible moves in applying a concept in classroom thought and talk, pupils develop a conceptual understanding of science concepts. In other words, in mastering the use of a concept and becoming aware of new and possible inferences along with related prohibitions or preclusions, pupils learn to play by the rules of the game.

The expert teacher is sensitive to how the inferential role of concepts in the norm-governed classroom talk assumes an *inferential mode* in teaching science. It is not pupils' induction into the *social language of science* or acquisition of technical vocabulary that is central to an inferential mode but rather their induction into norm-governed practices. Such normative practices involve navigating an entire network of compatible and incompatible relations- a *logical space of reasons* articulated in *believings, sayings and doings*. An inferentially-oriented teacher in approaching classification would be and ought to be aware that scientific terms or concepts are already always related to other propositions, in coherent and systematic ways governed by the norms of the knowledge domain and discourse in which they are applied. The cards are intended to alert teachers and learners to the systematicity of concepts and their application in primary science discourse and related activities as operating within a logical and normative space of reasons. These systematic relations serve to permit or preclude propositional inferences. These inferential rules constitute the concept meaning of relevant terms or claims in thought and talk. From an inferentialist view, the meaning of these scientific terms (conceptual content) lies not in the words, or references nor is it determined solely by their context-sensitive *use* (linguistic pragmatics) but is constituted by their rule-governed inferential *role* in reasoning expressed in thought and talk. The classification of card statements immediately foregrounds how the seemingly straightforward ideas of 'solid', 'shape', 'flow', 'materials' or 'proprieties' involve much more than initially assumed. Once these ideas are challenged or problematised, the need for resolution and demands for reasons and justification[75] is hard to ignore. This inferential space of reasons is not only logical but a socio-normative space. In an inferential mode in classroom talk, pupils are forced to take responsibility for their judgements and reasons articulated in what they think, say and do. The role of the inferentially oriented teacher thus lies not in simply assessing the correctness of her pupils' practical reasoning. Playing the game and inducting pupils into the normative space of scientific discourse consists in challenging, endorsing and calibrating her pupils' inferences and reasoning.

The proposed resources privilege inferences over representations in an approach to classification. These resources serve to explain what learners say and do by making explicit *reasons* underpinning their claims and actions as part of a systematic, logical semantic network of commitments, entitlements and incompatibility relations. The above analysis and resources illustrate an inferential network of claims, not as some fixed structure to be represented but as a more complex and dynamic *inferential* structure of reasons. These reasons are expressed through ongoing thought and talk with others and with ourselves, in articulating our reasons and inferential commitments through our discursive reasoning. Thus, the teacher approaching classification in an inferential mode is invested in making all her pupils aware of just what is involved in making scientific moves and participating in the activity and discourse. In short, teaching with classification as a practical activity involves more than merely sorting into discrete boxes, introducing new vocabulary or the appropriate use of technical language. An inferentially-oriented teacher is responsive to reasons that underwrite correctnesses and incorrectnesses of concept application such as solids or liquids or gases and the inferential reasoning articulated

[75] Brandom refers to us humans as rational and engaged in concept-mongering practices.

by pupils in undertaking judgments in the norm-governed activity of classifying materials.

5.5 Chapter Summary

In this chapter, I discussed different pedagogic approaches to classification in teaching and learning about materials in primary science. Drawing on Brandom's paradigmatic distinction between representationalism and inferentialism, I sought to problematise classification through an inferentialist lens. I introduced Brandom's theory of concepts as an alternative approach to concept-meaning tied to thinking and talk. I illustrated his inferential semantic interpretation of concepts, meaning and their application and how this illuminates the inferential nature of concepts as expressed in their use and role in thinking and talking within science classrooms. In short, as an explanatory account of concept-meaning, inferentialism privileges the role of the inferential over the representational. In doing so, I have sought to illustrate how inferential semantics makes explicit the logical, systematic, inferential structure and patterns that expose the perspectival nature of the rational, normative dimensions of concept-meaning in our concept-using practice, namely our reasoning expressed in our discursive practices. Through an inferential semantic account of science concepts, the reorientation of classification as an inferential activity served to foreground the inferential role of concepts in discursive reasoning (thought and talk) as opposed to surface-level performances, whether in practical activity or discursive practices. In this chapter, I focused on the conceptual content (meaning). In the next, I complement this discussion by attending to the discursive practices in which such concepts and meaning are not only formed and developed but also constrained and assessed.

6 Deontic Scorekeeping: Towards an Inferentialist Analysis of Discourse

While I discussed Brandom's theory of concepts in the last chapter, which focused on semantic aspects of our thought and talk, in this chapter, I focus on his theory of communication that attends to pragmatic aspects of our thought and talk, central to human communication. I aim to provide a fuller picture of Brandom's Inferentialist approach by demonstrating how his unique *normative pragmatics* complements his innovative *inferential semantics.* His *inferential semantics* addresses conceptual content (meaning) in terms of our rational judgments or reasoning. While Brandom's *normative pragmatics* provides an account of what we humans, as minded, rational agents, *do* in using concepts with others in thought and talk, aware of them as equally free-minded in making rational judgments. Thus, the focus on our discursive practice leads by addressing the normative character of using concepts in our discursive practices. In other words, concept meanings are not located in linguistic performance but in rational judgments not viewed as between the ears but exercised through social and discursive practices.

I introduce Brandom's *normative pragmatics* approach to describing discursive practices, following his philosophy of language and metaphor of linguistic communication as a *game of giving and asking for reasons* (GoGAR). He analyses discursive practices[76] using his favourite idiom of *deontic scorekeeping* (Brandom, 1994; Bransen, 2002). This is a sports analogy he draws from baseball, inspired by one of his mentors David Lewis. In baseball, scorekeeping is a way of keeping track

[76] As an aside, note that though we are paradigmatically dealing with linguistic performances, it need not necessarily pertain solely to verbal exchanges. The notion of *pragmatic significance* allows the application of this account to be rendered to any form of communicative exchange where norms (rules), normative statuses and normative attitudes (scores) are in play, such as gestures, models etc. (Loeffler, 2017).

of every move that occurs in the game, including players' turns, runs, strikes etc. The game never stops, and the scorekeeping runs in tandem with the game. As Bransen clarifies, Brandom's 'deontic scorekeeping' analysis involves taking the analogy of language as a game 'as seriously and literally as possible' (2002, p. 387). His scorekeeping model of our discursive practices is intricate. However, this is necessary to provide a vocabulary that describes the organic nature and dynamic structure of discursive practices involving free rational agents, like players in rule-governed games. In explaining his scorekeeping analogy with playing a game, I turn to address his normative vocabulary. It is this vocabulary, although technical, that begins to highlight how limited representational explanations and vocabulary are. I present his theoretical model below to illustrate how the *game of giving and asking for reasons* is not a simple metaphor that represents features of what we do. His metaphor of a game, particularly scorekeeping, aims to highlight just how dynamic our practices are, in ways that the representational approach fails to acknowledge. Brandom aims to provide a descriptive and explanatory account of our rational awareness and capacity for judgments, not only in relation to ourselves but in relation to others with rational autonomy. Brandom offers a model and vocabulary for our communicative or discursive practices, not just as a matter concerned with linguistics or pragmatics but as a specifically normative issue. I work through his technical model, setting out his vocabulary and terms that take the metaphor of playing a game seriously. This means offering up an account of thought and talk framed in terms of the *rules* of the *game*, *moves*, *scores*, *players* and *keeping score*, that is, playing a game. However, some differences should be discerned. Loeffler suggests that playing the game 'will not determine winners or losers' (2018, p. 62). This further reiterates the point that 'there is no super-scorecard' for the game

(Maher, 2012, p. 72), where a player 'will keep score accordingly as best as he can' (Loeffler, 2018, p. 67).

The scorekeeping analysis highlights how *reasons* are expressed, not just by utterances but by playing the game involving players and their attitudes. After introducing the scorekeeping model and technical aspects, I will then attempt to apply his vocabulary and analytic model to provide an inferentialist scorekeeping interpretation of classroom dialogue to illustrate the normative dimensions he describes. In providing a practical illustration of this scorekeeping analysis, I revisit Scott and Ametller's classroom dialogue on 'forces' (Scott and Ametller, 2007; See Chapter Two), albeit from an inferentialist perspective. This illustration segues into a critical discussion of inferentialist insights that sit in contrast to Mortimer and Scott's discourse analytic framework and dialogic meaning-making, an argument I continue in the next chapter. First, I turn to introduce Brandom's inferentialist theory of communication and his approach to analysing discursive practices.

6.1 Deontic Scorekeeping: Brandom's Theory of Communication

6.1.1 Discursive Practices as Deontic Scorekeeping

Brandom's theory of human communication introduces a radical shift in how our discursive practices are described. He views our discursive practices as bound by rules (norms), rules we collectively and socially institute and are obligated (*deontic*) to recognise in participating in linguistic exchange (Derry, 2017; Loeffler, 2018). Without rules, we could not engage in discussion. For example, imagine playing a chess game with no rules to regulate the moves of chess pieces on a chequerboard. Similarly, our language (semantics) and linguistic practices require rules for us to collectively participate in a coherent manner that allows us to communicate more or less successfully. Thus, Brandom refers to our discursive practices as *deontic practices.* In linguistics this expresses the notion of duty or obligation; the obligation to play by the rules that govern the correct usage of concepts or norms that govern or constrain our linguistic exchanges. In foregrounding this *normative* dimension, in offering an account of our concept-using discursive practices, understood as 'exchanges of types of performances between at least two participants' (Loeffler, 2018, p. 56), Brandom advocates his version of pragmatism, namely his *normative pragmatism* (Brandom, 1994; Loeffler, 2018; Maher, 2012).

Various authors have appraised Brandom's normative pragmatic approach to linguistic communication as 'boldly unorthodox and highly technical in nature' and maybe 'daunting for the beginner' (Loeffler, 2018) while viewed as an 'ambitious and elaborate' account by others (Maher, 2012). Given the sheer complexity of Brandom's model of discursive practices and philosophical vocabulary, I also enlisted support from several commentators, in particular prominent commentator Ronald Loeffler, who has been instrumental in developing my approach to an inferential interpretation of both conceptual content and discursive practices or thought and talk[77]. Scorekeeping as an analytic model not only attends to pragmatic performance but the pragmatic significance of asserting from the point of view of the agent or interlocutor (player). Brandom's paradigmatic inferentialist move is not an outright rejection of linguistic approaches but rather a reconfiguration of critical concepts, understandings, and interpretations of discursive practice. The nature of the discourse is not reified but viewed as inseparable from players that play the

[77] In fact, Brandom's account of language rooted in linguistics and logic is cited by Wanderer and Weiss (2010) as one of the reasons for its uptake being much slower than that of his colleague McDowell.

game. The emphasis is placed on the assertional nature of discursive practices, where the role of the agent or player is not only acknowledged but foregrounded. The rules of the games are not abstract free-floating entities but tied to players in playing the game, making moves, and responding to others' moves.

In analysing discourse or assertional practices, one needs to attend not only to assertions themselves but to the rational agent, who makes judgments and asserts claims. Brandom considers any assertion as simultaneously affecting one's own and other players' scores. In other words, such games are fundamentally a normative and interpersonal affair since playing the game and making assertions involves rules governing what players are allowed or required to do to communicate with other players. I have drawn on the deontic scorekeeping aspect to capture the crucial normative dimension of Brandom's description of discursive or deontic practices. This can now be understood as a practice involving scores (deontic statuses) achieved through moves (or changes in deontic attitude). Due to the limitation of space, I have limited the scope of Brandom's model, which is a far more complex, nuanced, and intricate account of linguistic communication. I merely sketch an outline of the deontic scorekeeping model below, focusing on critical aspects related to a worked example of a scorekeeping analysis of primary science dialogue on forces. I borrow Derry's phrase in claiming that I merely present the 'bare bones' of his account here. I have however, sought to expand in more detail on specific technical aspects of his model. This should provide a baseline for drawing a critical comparison between an inferentialist approach and MMF's sociocultural discourse analysis and developing a discussion of analytic and methodological issues as they relate to pedagogical issues, which I pursue in the next chapter.

6.1.2 Brandom's Analysis of Discourse

From Brandom's perspective, linguistic exchanges in classrooms are considered an example of the game – a social activity governed by specific ***rules*** (norms) in which we humans as ***players*** participate. For example, when the teacher asserts, 'Yeah! Forces start things moving.' this constitutes a *move* in the language game. The teacher's utterance or claim is an *assertion*; as such, it is a move in *the game of giving and asking for reasons*. Any *assertion* or linguistic performance (speech act) in the language game is considered a *move* made at each stage of the game (turn). Every participant, interlocutor, or, to use Brandom's terminology, every *player* has various *commitments* and *entitlements* to certain moves made in playing the game in accordance with the norms or the rules of the game (see Chapter Five). These rules determine permissible and impermissible moves in the game.

Speech Acts and Assertions: Edwards and Westgate (1994) discuss speech acts in their book 'Investigating Classroom Talk'. In the development of theories and techniques in the 'analysis of real talk', the authors acknowledge how approaches 'were at first philosophical in nature, and can be traced back to the seminal suggestions made by J.L Austin (1962) for clarifying 'what can be done with words'' (p. 21). In *How to Do Things with Words* (1975), which was published posthumously, Austin influenced philosophers and, subsequently, researchers began to pay more attention to the non-declarative use of language. Austin introduced a 'three-fold distinction between the *locutionary* and *illocutionary* force of an utterance, and its *perlocutionary* effect[78]', which led to approaches that offered 'new clarity to analysis

[78] The locutionary function can be taken to relate to 'literal meaning of an utterance' and 'broadly synonymous with 'semantic'. The second distinction acknowledges how the form of an utterance may be 'at variance with its illocutionary force', for example 'Is there any salt?' or 'Can you open the window?', the utterance is at variance with the implied request 'I would like some salt' or 'please open the window'. These are both to be

of the kinds of work which language can perform'. (Edwards and Westgate, 1994, p. 21).

In following his ideas, it was Austin's student, John Searle that developed the idea of *speech acts* (Searle, 1969, 1976). Edwards and Westgate (1994) acknowledge his contribution claiming that *pragmatics* and the 'allied field of *discourse analysis'* pay close attention to the social context of utterances, and that '[b]oth have their origins in speech act theory, and both have much to contribute to the analysis of classroom talk' (p. 21). I discuss the relation of speech acts to Mortimer and Scott's work and discourse analysis in the next chapter (see §7.1). For the present, I focus on introducing Brandom's use of the term 'speech act' in following in the tradition of philosophy of language and pragmatics. Brandom's aim however is to reorient our understanding of linguistics and pragmatics, i.e., with a normative twist.

Loeffler's commentary on Brandom's work provides a systematic summary of terms, making his complex vocabulary and account of our discursive practice more accessible. For Brandom, any instance of discursive practice forms part of the *game of giving and asking for reasons*, viewed as linguistic communication understood as the '[n]orm-governed social interaction between two or more participants'. (Loeffler, 2018, p. 244). The participants in playing the *game of giving and asking for reasons* are autonomous or 'self-legislating' rational beings, 'in that they give the norms of reasoning to themselves' (p. 244). In such autonomous discursive practice 'assertion is their only speech act'. (ibid., p. 244). For Brandom, 'propositionally contentful *speech acts*' are 'paradigmatically assertion', stating that:

distinguished from 'the perlocutionary effect which is produced', for example the passing of the salt of the opening of the window. (Edwards and Westgate, 1994, p. 21)

> Claiming or asserting is what one must do in order to give a reason, and it is a speech act that reasons can be demanded for. Claims both serve as and stand in need of reasons or justifications. They have the contents they have in part in virtue of the role they play in a network of inferences. (2001, pp. 161-162).

In playing this game, in giving and asking for reasons, his *linguistic rationalism* understands assertions as:

> …the fundamental sort of speech act, as essentially things that can both serve as and stand in need of *reasons*. Giving reasons for a claim is producing other assertions that *license* or *entitle* one to it, that *justify* it. Asking for reasons for a claim is asking for its *warrant*, for what *entitles* one to that commitment (Brandom, 2008, p. 114).

Brandom summarises this view when he states: 'Assertions are essentially, and not just accidentally, speech acts that can play the role both of premises and of conclusions of inferences.' (Brandom, 2008, p. 44). In playing the game, in discursive practices '[u]nderstanding a speech act—grasping its discursive significance—is being able to attribute the right commitments in response. This is knowing how it changes the score of what the performer and the audience are committed and entitled to.' (Brandom, 2001, p. 165). Brandom provides an inferentialist semantic vocabulary and an approach to modelling and describing our discursive practices, both as part of playing the game of giving and asking for reasons and involving players who keep score in what he refers to as *scorekeeping*.

Scores: These various commitments and entitlements are ***scores*** (normative statuses) in the game, that is, moves made in social and discursive practice. Each player is tracking moves and keeping score*.* Thus, each player has their point of view as well as their point of view on what others have said (normative attitude). The score is to be understood as *relational* and *perspectival*, where no one person's point of view on their own is privileged.

Scorekeeping: Every player keeps score, and to keep track of scores, players engage in two types of activities: *acknowledgements* and *attributions*. Acknowledgements address the scorekeeper's own reflection of her own deontic status (commitments and entitlements) at a given stage of the game. What she herself believes (commitment) and takes to have the permission, authorisation, or authority to think or say (entitlement). *Attributions* are the deontic status a scorekeeper takes other players to have at that stage of the game, the attribution of multifarious commitments and entitlements to other players. These *acknowledgements* and *attributions* by players constitute a scorekeeper's *deontic attitude* at each stage of the game – her point of view (her scorecard tracking moves and attributing scores) regarding her own position and an assessment of the constellation of beliefs and entitlements of other players. In Brandom's normative pragmatic vocabulary, 'scorekeeping is done by adopting certain kinds of *deontic attitudes (*normative attitudes) at each stage.' (Loeffler, 2018, p. 58). To sum up, at each stage, each player acknowledges for oneself and attributes to others a set of commitments and entitlements to players.

6.1.3 Brandom's Pragmatism and Normative Pragmatics

Brandom's philosophical project in explaining thought and talk can be characterised on the one hand, as a pragmatist perspective[79], the view that the 'key to understanding what makes us humans rational and capable of empirical knowledge is looking at our ability to communicate linguistically with each other.' (Loeffler, 2018, p. 2). On the other hand, in pursuing his project along pragmatist lines, Brandom follows the analytic tradition by attending to the technical details developed within the philosophy of language. So, while his pragmatism attempts to 'explain reason and meaning in terms of communication', in articulating and refining his 'pragmatist vision of language, reason and knowledge', it is his *normative pragmatics* that provides a descriptive model and detailed technical vocabulary that offers a unique, throughgoing and full-blooded account of our communicative practices (Loeffler, 2018, p. 4).

In Chapter Four and Five, I presented Brandom's fundamental theoretical commitments, that is, his perspective on pragmatism that explains concepts and meaning in relation to his inferential role semantics. Brandom views reason as irreducibly normative and instituted through social and discursive practices, that is by playing the game of giving and asking for reasons. According to Brandom, in playing this game, we humans engage in what he calls *scorekeeping*. This scorekeeping model of linguistic communication forms a fundamental account of his *normative pragmatics*. This scorekeeping model and vocabulary, his *normative pragmatics*

[79] This strongly aligns with Vygotsky's focus on thinking and speech while at the same time squarely focusing on 'the issues at the heart of theoretical modern Western philosophy: the nature of human reason and knowledge. Brandom attempts to 'tackle these issues in broadly Rortyan pragmatist terms – specifically, in terms of our ability to engage in linguistic, communicative social practices.' (Loeffler, 2018, p. 2).

‘describes the use of language in discourse in part in normative terms, that is, in terms of how the language should or may be used’ (Loeffler, 2018, p. 247).

6.1.4 Modelling Discursive Practice as Scorekeeping

In this section, I consider Brandom’s *normative pragmatics* in characterising how we play this game. His scorekeeping model, which is comparable to playing a game of chess, has been discussed above (See Chapter Four). Viewed as a game, discursive practices involve players making moves and responding to other players and their moves. The players and moves are not sufficient to describe *playing* the game. There are moves made implicitly by players, responsive to their own moves and prospective moves but also those of their opponent. Accounting for the players’ perspectives, not only in making moves but in tracking and responding to other players and their moves, is a normative practice, a deontic practice. To score, one needs to be a player participating in the game and make a move. There are various *types* of assertional (inferential) moves, a fundamental move being avowing or asserting a commitment. There are other moves, which serve as retractions (disavowal), deferral or auxiliary moves, which I address below. A move and score are related to players’ moves identified by the three-fold distinction between commitments, entitlements and incompatibility relations introduced in Brandom’s *inferential semantics*.

Fig. 14. Vocabulary for scores

In keeping score players *acknowledge* and *undertake* commitments for themselves whilst also attributing *acknowledged* or *undertaken* commitments and entitlements to other players.

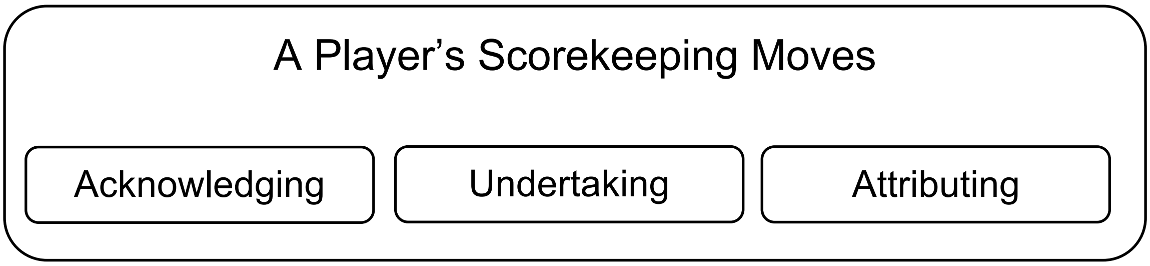

Fig. 15. Vocabulary for scorekeeping

I take a teacher as an exemplar of a scorekeeper. I have illustrated scores (claims) and scorekeeping moves (teacher’s perspectives) in the diagram below which can be used to visualise the scorekeeping process and model. In this example, the teacher is player T, and keeps score of her pupil (player P).

Teacher’s Scorekeeping Card[80]

Scorekeeping by Player T			
Scorecard for Player P1			
Acknowledging *for oneself* (T)		Attributing *to others* (e.g., P1)	
Acknowledged Scores	Undertaken Scores	Acknowledged Scores	Undertaken Scores

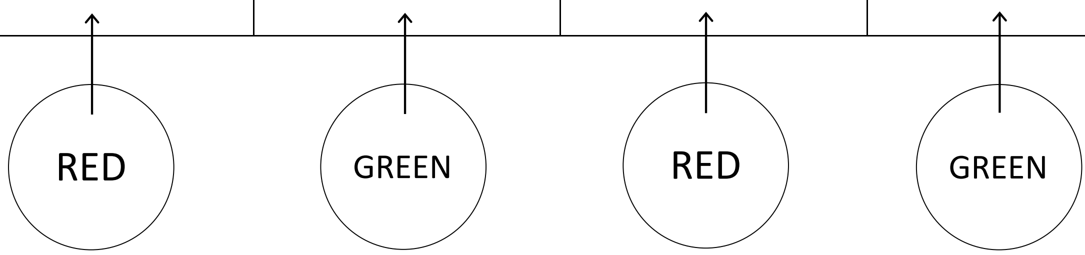

Fig. 16. A player's scorekeeping card

80 I have adopted and adapted diagrams proposed by Maher (2012) in his explanation of scorekeeping.

For example, consider someone (player P) shouts, 'Oh! Spider!'. This assertion Vx: Oh! Spider!' is indicated by a red chip. In keeping score, every player should record this move by placing the red chip for Player P under a commitment Vx as acknowledged. This would be akin to moving a chess piece. As with chess, all players keep score of their own moves and other players. The teacher, as Player T, places a red chip on the scorecard for Player P. She *attributes* that commitment (Vx), the red chip, to player P. Now, let us imagine T is the teacher knowledgeable about the inferential and permissible consequences of commitment Vx, such as a committive consequences 'spider has eight legs' (unacknowledged commitment), or permissive consequences 'spider is an arachnid' (unacknowledged entitlement). In this particular case, Player T as a science teacher acknowledging such committive *consequences* of Vx, in addition to scoring the red chip from what is said, may also score a green chip. In this case, Player T would score this inferential commitment as *undertaken* by P, but may not be acknowledged by P herself, but it is nonetheless attributed to her by the teacher. Herein lies the crucial distinction between *acknowledging* a commitment for oneself and *attributing* a commitment to another player. Although the exact same words are in use, the constellation of inferential commitments each player scores on their card is different, not just different between players' own commitments but those they take other players to be committed to.

In discursive practice, making an assertion has a score-changing potential for that player and other legitimate players. A move which does not change the score in the game is referred to as an auxiliary move, such as a *query.* A query is a move that may challenge or probe a move with no score-changing consequence. The particular way an avowal affects anybody's score depends on the player keeping score. Thus, scorekeeping practice marks the difference in perspectives between players of the game. Brandom refers to this as the ‘social-perspectival’ character of conceptual content (2001, p. 38). Different players as scorekeepers will not necessarily score a claim or an assertion in the same way. Subsequently, there is no overall score, no master scorecard, an external vantage point outside the game or a view from nowhere. The score is always scored by some player. Scorekeeping is a tricky business. Brandom’s communication model considers any assertion as affecting one’s score and other players’ scores. This constant changing, tracking, and scoring is an elaborate and complex process. The model captures the way in which discursive reasoning of a term, word, concept, or claim is never cast in stone. They are ideas, organic and dynamic life forms parasitic on our social articulation. With Brandom’s scorekeeping model in view, I demonstrate its application in analysing a dialogue extract from a primary science lesson on forces.

6.2 Scorekeeping in Primary Classroom: A Dialogue on Forces

6.2.1 Dialogue on Forces in the Primary Classroom

In this section, I explore how Brandom’s deontic scorekeeping model might be applied to an analysis of classroom dialogue. The scorekeeping approach introduces four key dimensions, namely, the game, players, their moves, and scores, and keeping score of the game. While these features may overlap with certain (representational) aspects of discourse analytic approaches, the scores and scorekeeping aspects illuminate the normative dimensions and offer inferentialist insights. I return to the forces dialogue discussed earlier (Chapter Two) to demonstrate an inferentialist analysis of classroom discourse, providing a *normative pragmatic* description of selected parts and scorekeeping commentary.

1. **Mrs Simon**: *You had a good go at thinking about forces. Just to remind you of what you – or you to remind me of what you got up to last week – what are forces? [Several pupils put up their hands and teacher nominates Jessica to answer.]*
2. **Jessica:** *A push or a pull?*
3. **Mrs Simon**: *Yeah! Pushes and pulls ... and forces, we, I'll just summarise what we did last week actually. Forces are needed to start things moving. Think about the things we did out in the yard. What else might they be used for?*
4. **Becky**: *Stop things moving.*
5. **Mrs Simon**: *Stop things moving. Can you think of any time when they stopped things moving? Give me an example of something that stopped ... something else moving ... last week?*
6. **Lyndon**: *A cricket bat stopped the ball.*
7. **Mrs Simon**: *The bat stopped the ball. And what else did forces do? In some of the activities? In this one [pointing again at Lyndon to refer to the cricket bat]. Mark?*
8. **Mark**: *The bat pushed the ball, once it stopped the ball it pushed it away.*
9. **Mrs Simon**: *How might you describe that? What did it do to the ball?*
10. **Becky**: *Maybe it stopped it and then it started it again.*
11. **Mrs Simon**: *Yeah! How?*
12. **Connie**: *Is it rebounding off it?*
13. **Mrs Simon**: *Kind of. How might we say that? How might we describe that movement? Ball comes from the bowler's hand to the bat ... what else is it doing to the ball?*
14. **Alex**: *Bouncing?*
15. **Mrs Simon**: *Hmm ... Yeah! Yeah! What ... how can we ... how else might we describe that?*
16. **Lyndon**: *It pushed it. It pushed the ball.*
17. **Mrs Simon**: *It pushed it from the bowler, didn't it? How did it change, once it's been stopped?*
18. **Becky**: *Direction.*
19. **Mrs Simon**: *It changed direction, didn't it? And at the end of last week we talked about measuring forces, how we might sometimes need to measure a force, and how we might sometimes need to consider the direction of a force. And I want to go on today to look a little bit more about directions of forces and also measurements of forces, and ... thinking all the time ... What forces are in action? What's happening here? What's making something start? What's making something stop? What's making something change direction? All right? Think about that all the time.*

6.2.2 Scorekeeping Analysis and Commentary

Scorekeeping analysis of dialogue considers any linguistic performance or speech act[81] as an *assertion* that constitutes a *move* in *the game of giving and asking for reasons*. These moves are made by players at each stage of the game or a 'turn' in the dialogue. Mrs Simon (teacher—- T) takes the first turn in this dialogue (indicated by '1.', see above), and I have identified her initial speech act as 'T1'.

(T1): **Mrs Simon***: You had a good go at thinking about forces. Just to remind you of what you – or you to remind me of what you got up to last week – what are forces? [Several pupils put up their hands and teacher nominates Jessica to answer.]*

Following a deontic scorekeeping account (DSK), this initial speech act is considered the teacher's (T) first move (T1) within the game. Any subsequent moves by the teacher, Mrs Simon, will be labelled consecutively, e.g., T2, T3 etc. There are two statements or claims Mrs Simon makes or *asserts* in playing the game, and I consider these each in turn.

i. *You had a good go at thinking about forces.*

ii. *Just to remind you of what you – or you to remind me of what you got up to last week – what are forces? [Several pupils put up their hands and teacher nominates Jessica to answer.]*

[81] I have not discussed conventional terminology Mortimer and Scott employ in their discourse analysis here. They were introduced and explained in Chapters Two and Three. A comparison critical discussion is conducted in the next chapter. The present chapter focus on introducing an inferentialist vocabulary.

i. You had a good go at thinking about forces.

Mrs Simon initiates the lesson by *asserting ‘You had a good go at thinking about forces’*. Opening up the conversation with pupils, her initial *assertion expresses* her belief (commitment) that they have engaged in thinking about ‘forces’. Her move *acknowledges* for herself and makes explicit to her pupils that she believes they all had the opportunity to ‘think about forces’. According to a DSK perspective, her assertion is not only a speech act, but an inferential move, expressing her commitment to the claim that everyone has thought about the concept of forces. Thus, her initial move is an *assertional commitment*. She would be obliged (committed) to reassert this very commitment/claim if asked about her pupils later in the conversation. The teacher establishes the topic of the conversation as concerning forces (the norm-governed game). From her perspective, her use of the term ‘forces’ invites or permits children to use it. In technical terms, she *entitles* them to use the concept ‘forces’ in relation to the present discussion.

ii. Just to remind you of what you – or you to remind me of what you got up to last week – what are forces?

As she sets the rules and initiates the game, the remaining part of her initial move involves raising a question. She asks her pupils to articulate their understanding of the force concept, with their commitments and entitlements. Thus, T1 is an ‘asking for reasons’ move that initiates a whole class discussion on the scientific concept of forces. At this stage, the game ‘kicks off’ so to speak. This second part of her move (T1) employs a ‘*query*’; as such it does not change the score of the game and thus constitutes an *auxiliary move*. The query following her *assertional commitment* that they had a ‘good go at thinking about forces’ allows her to initiate the game and set the rules governing the game; namely, a game constrained within scientific knowledge domain. At this stage of the game, ‘force’ remains in need of articulation.

As an initial step, I have sketched out the basic scorekeeping aspects in approaching a deontic scorekeeping analysis of the remaining dialogue from an inferentialist perspective that views classroom talk as a game of giving and asking reasons; as such, I addressed the following critical aspects of:

- **Game:** Initiating the Game
- **Rules:** Making Moves and Playing by the Rules
- **Scores:** Player Moves in Changing Scores
- **Players:** Players and Scorekeeping Moves

Initiating the Game and Setting the Rules

Brandom views us humans, as free-thinking reasoning beings and our discursive practices as a game we play in giving and asking for reasons. We are nevertheless constrained and bound by normative rules that we ourselves freely but collectively institute (Derry, 2017). He recognises this norm-instituting interaction of the social kind as involving our autonomy in our reasoning expressed in and through our social, rational and normative practice referred to as the ‘game of giving and asking for reasons’ (Brandom, 2001; 1994). In the present case, the game initiated is governed by the norms of the scientific concept and discourse of forces.

Making Moves as Playing by the Rules

Every *player* has various *commitments* and *entitlements* to certain moves made in playing the game, which *ought* to be in accordance with the rules (normative statuses). The (inferential) rules determine permissible and impermissible moves within the game and constrain the legitimacy of moves freely made by players. Suffice it to say here that the commitments and entitlements a player has in playing the game determines their score.

Player Moves in Changing Scores: Normative Statuses

Making moves that follow the rules subsequently changes the score in playing the game. There are two crucial components in scoring moves in these language games (a game of giving and asking for reasons), namely *commitments* and *entitlements*. Each player, at each stage of the game has ‘various commitments and entitlements to certain moves, in accordance with the norms governing the game. That is, each participant has certain deontic statuses (normative statuses).’. (Loeffler, 2018, p. 56)

Where the ‘constellations of commitments and entitlements, distributed over the participants at a given stage, is the *score* of the game at that stage. A legitimate move usually alters the score in certain ways, depending on the previous score, the type of move made, and who made the move.’ (ibid., p. 58).

Players and Scorekeeping Moves: Normative Attitudes

Each ‘competent player’ sensitive to the rules of the game, participates appropriately by ‘*keeping score* implicitly in practice, that is, by tracking the various participants’ deontic statuses throughout the exchange. Scorekeeping is done by adopting certain kinds of *deontic attitudes* (normative attitudes) at each stage.’ (Loeffler, 2018, p. 58). A scorekeeper ***acknowledges*** multifarious commitments and entitlements to certain moves for oneself and also ***attributes*** multifarious inferential moves to other players. Each player keeps score on every other player. ‘The score kept by a participant at a given stage is the participant’s perspective on the real score of the game at that stage.’ (ibid.). Scorekeeping is thus, players’ attitudes to the score made by oneself and other players, at every stage of the game. The scorecard is constantly updated with every move by every player but remains implicit attitudes on assertions made explicit in dialogue.

(1.) Teacher asks a question and initiates the discussion: Summary Analysis of T1.

Thus far, I have focused on providing an interpretation of the dialogue as a *game of giving and asking for reasons*. The tracking and keeping of scores figure more prominently in subsequent moves. If I summarise the game at this stage, Mrs Simon has made two types of moves or speech acts according to the DSK characterisation: an initial *assertion* followed by a *query*. The initial move constitutes classroom talk, and the latter part initiates the game to be played, an entry into the science conversation proper. In the first part of her move, in making an assertion, a commitment, she acknowledges this commitment through an avowal. As she *acknowledges* this *assertional commitment* for herself and her class, the score derived from this linguistic move is an assertional commitment (C1). Simultaneously, her avowal, from her point of view, entitles or permits her pupils the use the term 'forces' (E1). Whether pupils' use of the force concept is in alignment with the teacher's *inferential commitments* and rules of the game, that is, the knowledge domain of science remains to be seen. In playing the game with pupils, she intends to keep score of their moves while challenging and endorsing their inferential commitments according to the norms of primary science discourse. As she probes children's commitments, her move involves a *query,* 'what are forces?' and she initiates the game by making the first move (T1), asking for reasons (AR_1).

Summary of Mrs Simon's Score:

Mrs Simon's initial ***move*** (T1) constitutes the first move in the game (GoGAR), where she asks for reasons (AR^1). The ***types*** of speech acts (Move Type) involved in her linguistic moves are Assertion (As^1) and Query (Q^1). In classroom talk, Mrs Simon ***scores*** an Assertional Commitment (C1) and is entitled by default but also entitles her class to the claim they ‘had a good go at thinking about forces’ (E1). Mrs Simon's ***scorekeeping moves*** (normative attitudes) as a teacher involve:

- **Acknowledges** her own commitment (C1) that her class ‘had a good go at thinking about forces’.
- **Attributes** her class as undertaking commitment (E1) that they ‘had a good go at thinking about forces’. By endorsing the term, in using it herself, she also permits her pupils to use the term appropriate to the norms of discourse and inference.

She ends her move with an auxiliary move, a *query* that does not change the score of the game, by asking, ‘What are forces?’. Now, below, I tabulate these moves and scores (see Table 8 and 9.). I also provide codes, not because this is what scorekeeping focuses on. I offered these to illustrate how the representational dimension can still be retained on a scorekeeping approach but is subsidiary to the analysis. Central to the analysis are not representational forms or codes of what is said but the judgments, relations, and adjustments we make in response to claims as a network of presuppositions held articulated and updated with every move by every player.

Summary Tabulation of Mrs Simon’s Score (T1):

Scorekeeping Moves	**Description of Moves – Player T**	**Codes**
A. GoGAR Move	Mrs Simon, asking for reasons	AR^1
B. Move Types	(T1) i. Assertion (T1) ii. Query	As^1 Q^1
C. Score	Assertional Commitment	(C1)
D. Scorekeeping (Mrs Simon)	***Acknowledges*** her own commitment ***Attributes*** her class as undertaking commitment	(C1) (E1)

Table 8. Summary Tabulation of Mrs Simon's Score (T1)

Mrs Simon's Scorecard at (T1)

	GoGAR Move (T1)	Types of Move	Deontic Score	Scorekeeping	Code
T1	AR_1	As^1	(C1)	*Acknowledges*	(C1) (E1)
		Q^1		*Attributes*	(C1) (E1)

Table 8. Mrs Simon's Scorecard (T1)

(2.) Jessica believes forces to be 'a push or a pull'

2. Jessica: A push or a pull?

Jessica responds to the question by claiming, 'a push or a pull?'. This is her first speech act (J1) in this dialogue. In responding to the teacher's question, her move is 'giving a reason', though she may be unsure. Thus, Jessica's move is illustrated as follows:

J1: *A push or a pull?*

At this stage of the game, from Jessica's point of view, she believes 'forces' are 'a push or a pull'. In making her ***assertion,*** she ***acknowledges*** her own ***commitment*** for herself and is made explicit for others engaged in the dialogue, that is, other players. The assertion does not express the entirety of Jessica's belief about forces but is only her initial articulation. What is entailed by this claim and related terms ('push' and 'pull') has not been expressed by this (single) utterance, and according to Brandom's big idea, it cannot be without consideration of its relation to other claims. In brief, what the forces mean for her requires articulation and playing the game of ***giving and asking for reasons***.

Acknowledging Commitments

Commitment is the first fundamental component of the deontic scorekeeping model. An *assertional commitment* is understood as a "speaker's commitment to an assertion or declarative sentence that p. Roughly, his or her obligation to assert that p when asked whether p." (Loeffler, 2018, p. 243).

The act of assertion is an acknowledgement, but she may also believe (*undertaken but not acknowledged*) that forces must involve physical contact. She may not be aware of these beliefs (undertaken) and thus, this belief remains implicit but undertaken nonetheless and may be acknowledged later in the game. Considering Jessica's first move (J1), she asserts 'push or a pull?', she explicitly *acknowledges* for herself a *commitment* to that assertion, such that if she is asked about forces, she would be obligated to make the assertion 'forces are push or a pull', or at least awaiting an endorsement. According to Brandom's scorekeeping analysis, her assertion (utterance) is an articulation of her beliefs (commitments), which serve as reasons in her thinking and use of the concept force (inferential reasoning), with which she responds to Mrs Simon's *query*. Jessica's move (assertion), her speech act (J1), is her response to the teacher's move (query), asking what forces are. She has made an ***assertional commitment***. What Jessica herself considers 'forces', 'pushes' and 'pulls' to be, remains open. However, what other players can take away at this stage, including the teacher, is that what Jessica takes to be 'forces' are 'pushes or pulls'. I have tabulated her move in summary below.

Summary of Jessica's Score:

Jessica's first move (J1) constitutes the second move (indicated in hyper script) in the game that gives a reason (GR^2). Types of speech act involved are Assertion (As^2). In making her assertion, Jessica scores an Assertional Commitment (C2) and, by so doing, is entitled by default to force as 'A push or a pull' (E2). Jessica's Scorekeeping (normative attitudes) moves involve:

- **Acknowledges** her own commitment (C2) that forces are 'a push or a pull'.
- **Attributes** to her class and class acknowledging *her* commitment (C2) but still to be endorsed by the teacher.
- **Attributes** to her class and class acknowledging a default entitlement to (C2), though it may turn out to be an attitude she ought not to have.

Summary of Jessica's Score (J1):

Scorekeeping Moves	**Description of Moves – Player J**	**Codes**
A. GoGAR Move	Jessica gives reason	GR^2
B. Speech Act Types	J1: Assertion	As^2
C. Score	Assertional Commitment	(C2)
D. Scorekeeping (Jessica)	***Acknowledges*** her own commitment ***Attributes*** to her class/teacher as acknowledging her commitment ***Attributes*** to her class/teacher as acknowledging default entitlement to C2	(C2) (C2) (E2)

Table 9. Summary of Jessica's Score (J1)

Jessica's Scorecard at (J1)

	GoGAR Move (J1)	Types of Move	Deontic Score	Scorekeeping
J1	GR^2	As^2	C2	*Acknowledges* (C2) (E2)
				Attributes (C2)
				Attributes (E2)

Table 10. Jessica's Scorecard at (J1)

Moves from (3.) – (17.): Development of Dialogue

As this analysis serves as an exploratory illustration and due to the limitation of space, I move directly from the opening two moves to the final closing moves. For a few more examples of detailed play-by-play analysis, please see Appendix 4.

(18.) Becky asserts 'Direction.', giving her reason from her point of view for how the ball changed after it had been stopped.

(B3) ***Becky:*** *Direction.*

Becky responds to Mrs Simon's question, '*How did* ***it*** *change?*' by asserting 'Direction'. From Becky's point of view, she *attributes* to Mrs Simon and her *query* a commitment to '*movement'* following from previous moves. She responds accordingly, taking the query to mean 'How did [the movement of the ball] change?'. The inference she draws *acknowledges* there has been a *change* in the ball's movement, and that change is described by 'direction', which informs her reason-giving move. Becky's single-word response discloses little regarding the commitments she maintains, explicitly or implicitly, at this stage of the game. However, Becky has thus far been one of the more active players in the game. Following the moves in the game, she takes the score of the game thus far as the 'bat struck the ball', the 'ball was moving before being struck' and 'on being struck was stopped and pushed away'. She subsequently concludes as or reasons, a consequence of interrelation of previous claims (committive consequence), not just the ball but, more precisely the ball's movement or trajectory changes direction. Such commitments have not been made explicit by Becky's assertion. At this stage, her one-word response simply names what she believes to have changed. Any other related commitments that support her assertion remain implicit for now. Whether Becky can differentiate between the idea of the ball as an object and movement as motion caused by forces, that is, the movement of the ball as opposed to the ball itself, and their interrelation to the concept of change in motion has not been made explicit. Thus, there remains ambiguity about what exactly Becky means or even understands by her one-word response. To assess or determine what Becky means, not just what she says but her inference-making expressed in her claim-making assertion requires further moves in playing the game. It requires the teacher to ask her for reasons for her assertion in making her inference. However, I present Mrs Simon's actual response to this one-word response in the concluding move of the game below.

Summary of Becky's Score (B3):

Scorekeeping Moves	Description of Moves – Player B	Codes
A. GoGAR Move (B3)	Becky gives reason	GR[18]
B. Speech Act Types in (B3)	B3: Assertion	As[18]
C. Score	Assertional Commitment	(C13)
D. Scorekeeping (by Becky)	***Acknowledges*** her own commitment	(C13)
	Attributes to her class/teacher as acknowledging commitment	(C13)
	Attributes to her class/teacher as acknowledging default entitlement to C13	(E13)

Table 11. Summary of Becky's Score (B3)

Becky’s Scorecard at (B3)

	GoGAR Move (B3)	Types of Move	Deontic Score	Scorekeeping
B3	GR[18]	As[18]	(C13)	*Acknowledges* (C13)
				Attributes (C13)
				Attributes (E13)

Table 12. Becky’s Scorecard at (B3)

(19.) Game Ends: Teacher endorses Becky’s move and settles the score

Mrs Simon*: It changed direction, didn’t it? And at the end of last week we talked about measuring forces, how we might sometimes need to measure a force, and how we might sometimes need to consider the direction of a force. And I want to go on today to look a little bit more about directions of forces and also measurements of forces, and ... thinking all the time ... What forces are in action? What’s happening here? What’s making something start? What’s making something stop? What’s making something change direction? All right? Think about that all the time.*

Mrs Simon’s response endorses Becky’s claim and entitles her and the class to the term ‘direction’. The teacher, at this stage, does not seek to clarify further Becky’s claim and presuppositions, which leads to her conclusion. From the science teacher’s point of view, Mrs Simon attributes to Becky an acknowledgement that direction is what changed. Her endorsement of Becky’s response is viewed as providing the *description* she has sought since Turn 7. While Becky may have gained an entitlement in calling out the term ‘Direction!’, the related claim ‘the ball changed direction’ remains implicit. The scorekeeping analysis highlights how *reasons* are expressed, not just by utterances but by playing the game involving players and their attitudes. Mrs Simon’s response, ‘It changed direction, didn’t it?’, though it serves as an endorsement, remains unclear whether the inferential role of the force concept has been made explicit for the class or Becky.

i. Mrs Simon: It changed direction, didn’t it?

- Mrs Simon acknowledges and endorses Becky's commitment (C13) and thus entitles Becky's claim from her science-teacher perspective, 'It changed direction, didn't it?' (E13)

What Becky acknowledges as having changed direction has not been made explicit but assumed and attributed *to* Becky *by* the teacher from *her* science teacher's point of view. Becky may have believed that *'it'* changed direction, understood as the ball changed direction. This does not necessarily entail a relation to force for Becky. In the primary classroom, children sometimes say and believe all manner of things in unexpected and unrelated ways (Donaldson, 1978). This point is reflected in Loeffler's comment on scorekeeping that the '…kept score will by and large agree with the real score, but it will also usually deviate from it here and there. The participant's scorekeeping attitudes may be mistaken in some respects, given the norms of the game (MIE[82] 182–6).' (2018, p. 58). This is crucial to an understanding of classroom talk, teaching and learning.

Summary of Mrs Simon's Score (T10):

Scorekeeping Move	**Description of Move – Player T**	**Codes**
A. GoGAR Move	Mrs Simon giving reasons	GR[19]
B. Move Types	T10 i. Assertion	As[19]
C. Score	Assertional Entitlement	(E13)
D. Scorekeeping (Mrs Simon)	***Acknowledges*** her own Entitlement ***Attributes*** her class as undertaking the Entitlement	(E13) (E13)

Table 13. Summary of Mrs Simon's Score (T10)

[82] MIE is an abbreviation for Brandom's Making It Explicit (1994).

Mrs Simon's Scorecard at (T10)

	GoGAR Move (T1)	Types of Move	Deontic Score	Scorekeeping	
T10	AR[19]	As[19]	(E13)	*Acknowledges*	(C13) (E13)
		Q[19]		*Attributes*	(E13)

Table 14. Mrs Simon's Scorecard at (T10)

The meaning of the force concept is not given by a single word or term nor a phrase or definition. On an inferential semantic view, its meaning is constituted by its logical relation between a constellation of claims and the role it plays in thought and talk in a *logical space of reasons*. In deontic practice or classroom talk, the meaning of the force concept is socially perspectival, relative to each player and their constellation of commitments and entitlements, that is, their deontic score. Each player will have their own perspective on how to apply that concept in discourse, that is, in their thought and talk with others. The correctnesses of concept application is not determined by oneself, however, but by the rules of the game, the scientific knowledge domain. Mrs Simon concludes the class by giving reasons *why* the idea of direction is essential in relation to thinking about forces. The term 'direction' is inferentially related to all the ideas about forces expressed and articulated by players in this dialogue. This is also related consequentially to the next phase, where the teacher seeks to amplify and justify their reasoning about force as related to 'measuring forces' and 'how we might sometimes need to consider the direction of force'. With this concluding move, I summarise the above DSK analysis and inferentialist insights in understanding the development of the force concept in classroom dialogue.

6.2.3 Deontic Scorekeeping Analysis Summary

	Representational Dimension				**Inferential Dimension**			
					Pupils Discursive Reasoning	**Teacher Endorsements**		**Teacher Challenge**
SI #	Speech Act	Player Move	GoGAR Move	Speech Act Type	Pupil Commitments	Teacher Entitlements	Teacher Commitments	Teacher Query/ Incompatibilities
1	**Mrs Simon:** You had a good go at thinking about forces. Just to remind you of what you – or you to remind me of what you got up to last week – what are forces? [Several pupils put up their hands and teacher nominates Jessica to answer.]	T1	AR	As[1] Q[1]			(C1) Forces	
2	**Jessica:** A push or a pull?	J1	GR	As[2]	(C2) Forces are pushes and pulls			
3	**Mrs Simon:** Yeah! Pushes and pulls ... and forces, we, I'll just summarise what we did last	T2	GR AR			(E2) Forces are pushes and pulls	(C3) Forces are needs to *start* things *moving*	

	week actually. Forces are needed to start things moving. Think about the things we did out in the yard. What else might they be used for?							
4	**Becky:** Stop things moving.	B1	GR		(C4) Forces are needed to *stop* things *moving.*			
5	**Mrs Simon:** Stop things moving. Can you think of any time when they stopped things moving? Give me an example of something that stopped ... something else moving ... last week?	T3	GR AR			(E4) Forces are needed to *stop* things *moving.*		
6	**Lyndon:** A cricket bat stopped the ball.	L1	GR		(C5) Cricket bat stopped the ball.			
7	**Mrs Simon:** The bat stopped the ball. And what else did forces do? In	T4	AR			(E5) The bat stopped the ball.		

	some of the activities? In this one [pointing again at Lyndon to refer to the cricket bat]. Mark?							
8	**Mark:** The bat pushed the ball, once it stopped the ball it pushed it away.	M1	GR		(C6) Bat pushed the ball away			
9	**Mrs Simon:** How might you describe that? What did it do to the ball?	T5	AR			(E6) Entitlement not acknowledged		(Q6) How to describe what it (bat) did to the ball?
10	**Becky:** Maybe it stopped it and then it started it again.	B2	GR		(C7) It (bat) stopped it (ball) and started it again.			
11	**Mrs Simon:** Yeah! How?	T6	AR			(E7) Bat stopped it (ball) and started it again.		
12	**Connie:** Is it rebounding off it?	Con1	GR		(C8) It (ball) is rebounding off it (bat)			
13	**Mrs Simon:** Kind of. How might we say that? How might we describe that movement?	T7	AR			(E8) It (ball) is rebounding off it (bat)	(C9) *Movement* unacknowledged: Bat-Ball starting, stopping is a movement	

	Ball comes from the bowler's hand to the bat ... what else is it doing to the ball?							
14	**Alex:** Bouncing?	A1	GR		(C10) Another Movement is bouncing			
15	**Mrs Simon:** Hmm ... Yeah! Yeah! What ... how can we ... how else might we describe that?	T8	AR			(E10) Bouncing is a movement		
16	**Lyndon:** It pushed it. It pushed the ball.	L2	GR		(C11) It (bat) pushed the ball			
17	**Mrs Simon:** It pushed it from the bowler, didn't it? How did it change, once it's been stopped?	T9	AR			(E11) It (bat) pushed the ball	(C12) Movement *changed*	
18	**Becky:** Direction.	B3	GR	As[18]	(C13) Direction			
19	**Mrs Simon:** It changed direction, didn't it? And at the end of last week we	T10	GR	As[19]		(E13) Direction Unacknowledged: the change in movement is due		

	talked about measuring forces, how we might sometimes need to measure a force, and how we might sometimes need to consider the direction of a force. And I want to go on today to look a little bit more about directions of forces and also measurements of forces, and ... thinking all the time ... What forces are in action? What's happening here? What's making					to forces acting on the motion of the ball by the ball.		

Table 15. Deontic Scorekeeping Analysis Summary

6.3 Deontic Analysis and Scorekeeping Insights: An Inferentialist Commentary

My proposed approach to scorekeeping analysis, demonstrated above, is by no means meant to be comprehensive nor exhaustive. It simply presents an exploratory attempt at applying the deontic scorekeeping model in analysing the dialogue. This modest undertaking, I claim, highlights key inferentialist insights for thought and talk in teaching and learning primary science. It also has key theoretical and analytic implications for conceptualising meaning-making and Mortimer and Scott's sociocultural framework, which I discuss in the next chapter. In analysing the force dialogue, I drew on four key aspects of deontic scorekeeping, which were:

1. Move in the Game: A GoGAR Move captured in more typical representational terms.
2. Type of Move: As a linguistic move remains a representation
3. Deontic Score: An inferential move made explicit in the game
4. Deontic Scorekeeping: A perspectival status relative to players and moves made

Before discussing these various aspects, I present an 'at-a-glance' summary of the deontic analysis presented in the previous section.

6.3.1 Summary of Deontic Analysis of Discourse

Pupil Moves– ***Grey bold italics***
Teacher Moves – *in italics*

Turn	Players Move	Inferential Moves
(1)	Teacher asks a question and initiates the discussion	*(C1) Forces*
(2)	Jessica believes forces to be	***(C2) Forces are a push or a pull***
(3)	Teacher agrees with Jessica and endorses her claim	*(E2) Forces are a push or a pull* *(C3) Forces are need to starts things moving*
(4)	Becky believes forces	***(C4) Forces are needed to stop things moving.***
(5)	Teacher entitles Becky, and asks class for justification	*(E4) Forces are needed to stop things moving.*
(6)	Lyndon gives **'bat stopped ball'** example and according to the teacher, thus justifies belief 'forces stops things moving'	***(C5) Cricket bat stopped the ball.***
(7)	Teacher endorses Lyndon and he earns an entitlement. Teacher asks class for related consequences of forces	*(E5) The bat stopped the ball.*
(8)	Mark believes a related consequence is that the '**bat also 'pushed the ball' 'it pushed it away'**	***(C6) Bat pushed the ball away***
(9)	Teacher follows up (entitles by default) Mark assertion, asking related reasons (committive consequences)	*(E6) Default Entitlement not acknowledged*
(10)	Becky asserts (acknowledges)	***(C7) It (bat) stopped it (ball) and started it again.***
(11)	Teacher entitles Becky, queries Becky/Class for reasons (inferential commitment)	*(E7) Bat stopped it (ball) and started it again.*
(12)	Connie believes infers the reason as **'rebounding'**	***(C8) It (ball) is rebounding off it (bat)***
(13)	Teacher gives related reasons and asks for an inferential committive consequence [Teachers reason remains implicit]	*(E8) It (ball) is rebounding off it (bat)* *(C9) Movement unacknowledged*
(14)	Alex seeks entitlement for his inference **'bouncing'**	***(C10) Another Movement is bouncing***
(15)	Teacher entitles Alex commitment and asks for a related commitment (inferential committive consequence)	*(E10) Bouncing is a movement*
(16)	Lyndon asserts **'It pushed it'**	***(C11) It (bat) pushed the ball***
(17)	Teacher entitles Lyndon from her point of view, gives related reasons and continues to seek an answer from her point of view (inferential committive consequence)	*(E11) It (bat) pushed the ball* *(C12) Movement changed*

(18)	Becky asserts **'Direction'**, giving her reason from her point of view for how the ball changed after it had been stopped.	***(C13) Direction***
(19)	Game Ends: Teacher endorses Becky's move and settles the score	*(E13) Direction Unacknowledged: the change in movement is due to forces acting on the motion of the ball by the ball.*

Table 16. Summary of Deontic Analysis of Discourse

6.3.2 Scorekeeping Analysis and Insights

To reiterate the point I made earlier, in *playing* the game and keeping score, there is no master card and no point of view from nowhere. Scorekeeping is a socially-perspectival affair. On a scorekeeping account, every move is an assertion made by a player, not just a free-floating utterance. Thus, every move is relative to some player and scorekeeping is undertaken by every player. A scorekeeping analysis immediately foregrounds moves, not only as utterances but as made by a player. In this game, other than the teacher (T), Becky (B) made the most moves in the game. From a scorekeeping analysis, my interpretative scorekeeping is made relative to the Teacher's point of view; Becky gains the most significant number of entitlements. The consequence is visible in dialogue as Becky also makes the defining move at Turn 18 (B3) by making an inference and asserting 'Direction'.

Teacher Scorekeeping and Teaching Focus

In my analysis, the scorekeeping is being interpreted from the teacher's perspective as a scorekeeper. Scorekeeping is always someone's perspective- there is no third-person abstract perspective. This analysis illustrates how the teacher's inferential commitments in articulating the concept force in classroom dialogue dictate her teaching focus and intention. She starts to discuss forces and systematically relates them to movement, changes in movement and direction. These moves were illustrated in the teacher commitments, C1, C3, C9, and C12. There is a cumulative entitlement that develops from Forces (C1) related to 'moving' (C3) and 'movement' in T7 (turn 13). Although this was an auxiliary move and as a query, this entitlement may remain implicit for the teacher and was not made explicit to her pupils. In this sense, (C9) – 'How might we describe that movement', was undertaken by the teacher but left unacknowledged for and by her pupils. However, from the teacher's perspective, she may have felt they had undertaken this commitment for themselves. In developing this idea, however, at T9 (turn 17), she sets the idea of movement by relating it to change (C12) – 'how did it change?'. At this stage, Becky asserts the (C13) 'Direction', which Ms Simon endorses, bringing the discussion to a close. This systematicity expresses the logical relations that constitute space in which the inferential role of the force concepts is articulated in classroom discourse and constrained by the norms of the science classroom. The application of force in this normative space allows the teacher to lead her pupils into her next phase in the teaching sequence, where the force concept is inferentially related to movement and measurement of force using newton meters, as discussed in her plenary. The scorekeeping analysis reveals and exposes not just discursive moves but the inferential move that the teacher makes that animate her moves and responses. It shows the teacher's focus, culminating in her final move endorsing the role and significance of direction in thinking about forces.

Discursive Ambiguity of Force Concept

Mrs Simon, in turn 9, in response to Mark's assertion, does not acknowledge an entitlement to him nor the class but immediately moves to a query, 'How might you describe that? What did it do to the ball?'. She does not change the score when making an auxiliary move (query). We have Mark's assertion that the 'bat pushed the ball away' and the subsequent query 'What did **it** do to the ball?'. There is a certain ambiguity, as the term 'it' has not been made explicit. This may seem trivial, but the issue becomes pronounced in subsequent moves. Becky's reply is, 'Maybe **it** stopped **it** and then **it** started **it** again.'. Scorekeeping recognises how terms and their meaning in use are not accounted for by their use alone (pragmatics), but it is socially perspectival. Each player has a different set of commitments and entitlement (score) constituting concept meaning and its application. However, its correctness is determined by the norms governing the discourse, not by players. So, where the teacher asserts, 'Yeah! How?' in endorsing Becky's claims, the teacher, from her scientific point of view, scores what Becky says as correctly *meaning* (C7) – **It** (bat) stopped **it** (ball) and started **it** (ball) again. However, this is assumed by the teacher, who *attributes* such background to Becky as not only *undertaken* but *acknowledged*, and she responds, 'Yeah, how?'. She entitles Becky to the assertion the teacher attributes as '**It** (bat) stopped **it** (ball), and **it** (bat) started **it** (ball) again. The ambiguity remains, while in turn 13 (T..), we see Mrs Simon moving from querying the inferential role of forces, slipping into a representational mode, which focuses on a more specific term she has in mind, namely 'direction'. Such an approach could be identified with a 'guess what's in my head' strategy (Wellington and Ireson, 2013, p. 5). From an inferentialist perspective, the primary issue is when Becky utters the target term in turn 18, the reasons Becky has committed to and articulated remain implicit in her one-word response, which Mrs Simon considered as an expression of a correct thus meaningful understanding. The issue with 'guess what's in my head', one-word answers sought through dialogue, is that saying the target word does not express what the child means and, more importantly, their conceptual understanding. In view of the ambiguity of terms, approaches to classroom talk that involves one-word responses or guessing the word, risks teaching interactions that slip into a representational mode, neglecting the inferential relations articulated in using the concept ‘forces’. Grasping the significance of pupils’ thought and talk requires the teacher, as an expert scorekeeper, to explore their claims as an inference that follows from a network of inferentially related previous claims. In playing the game according to the rules, that is, in placing claims within the space of reasons, the teacher appreciates how one-word responses are insufficient by themselves. The teacher engages in dialogue as a form of checking and assessing the constellation of their inferential commitments. The expert teacher would not only elicit and evaluate pupils’ responses; she begins to problematise and obscure their presuppositions in moving their thinking on. Beyond the ambiguity issue, we also notice that Mrs Simon’s challenges are all queries or auxiliary moves. The teacher not only seeks to help them gain entitlements but actively seeks to weed out incompatibilities in their thinking articulated in classroom talk. The inferentially-oriented teacher is not limited to linguistic or discursive patterns[83]. The teacher’s response may involve an extended dialogue (IRF chain), which begins to highlight tensions or incompatibilities in pupils’ inferential commitments. In making their incompatibilities explicit, the teacher develops pupils’ critical reasoning, allowing her to adjust their commitments and entitlements, thus amplifying their reasoning by extending their justificatory reasoning. In this manner, she not only calibrates their use of concepts but inducts them into a larger space of reasons, implications, and degree of freedom in thought and talk of forces or science concepts.

[83] I refer to the triadic discourse patters of initiation, response and evaluation or IRF, initiation, response and feedback discussed by Mortimer and Scott, see Chapter Three.

6.4 Summary Overview

The deontic scorekeeping interpretation illustrates Mrs Simon's discursive interactions with her class, couched in terms of the inferentialist metaphor of playing a game of giving and asking for reasons and the socially perspectival nature of scorekeeping. Brandom's inferentialist account and a scorekeeping interpretation of interpersonal discourse are less concerned with what MMF manages to do well, i.e., making visible various communicative approaches. I have illustrated how this approach is compatible and neatly aligns with the discourse analytic approach of MMF. However, the central insights of inferentialism lie in attending to those aspects absent in Mortimer and Scott's discourse analytic approach, namely the inferential structure of the concept application and the normative character of our discursive (deontic) practices. The game has rules, the norms governing moves players make, and the claims they assert within this norm-governed discourse. The scorekeeping analogy and analysis illustrate four key points that are summarised here in bringing the conclusion to a close:

1. **Game:** Discourse is not only playing the game but involves players, all playing by the rules and each keeping score.
2. **Rules:** Inferential Structure and Logical Space of Reasons
3. **Moves:** Normative Practice and Socially Perspectival
    a. Pupil Moves from Teacher Perspective
    b. Teacher Moves and Teaching Intention
4. **Scorekeeping:** Discursive Practice as Assertional Practice and Normative Assessments—- The game and norm-governed moves are always open to challenge and assessment.

An inferential account not only offers an approach inclusive of the representational approach that MMF makes visible. There is an inferential structure by virtue of commitments in our assertive practices as part of a deontic practice. The deontic scorekeeping analysis not only makes visible but, more importantly, makes explicit these structures that remain implicit in our discursive practices. The critical insight here is that if we wish to inform teachers and develop their practice, it is not enough to attend to these representational features merely but requires responding to the inferential patterns, which manifest not in virtue of linguistic pragmatics but as normative pragmatics. The difference between these two approaches is central in comparing scorekeeping with MMF. This is the focus of my critical discussion, which I present in the next chapter.

In sum, a scorekeeping analysis of classroom dialogue as a *game of giving and asking for reasons* governed by norms reveals an inferential structure present within the assertional practices, which simultaneously serves to normatively constrain discourse. This inferentialist perspective illustrates how teachers need to be constantly receptive and responsive to not only the inferential role of concepts in reasoning but their role as part of normative practices of classroom talk. For the inferential-oriented teacher, the inferential articulation within a space of reasons is the central focus, rather than words, technical language, definitions or references. In challenging and endorsing pupils' reasons articulated in discursive practice, the teacher aims to develop their inferential orientation to the knowledge domain and concept mastery. The classroom talk aims to initiate them into a space where they are not only aware but responsive to the norms governing discourse and to the inferential role of concepts, their use and articulation in classroom talk.

7 Normative Pragmatics of Discourse: A Critical Discussion

In continuing to develop the scorekeeping analysis introduced in the previous chapter, I initiate a critical discussion comparing Mortimer and Scott's analytic approach to classroom talk with the scorekeeping approach. I aim to illustrate how an inferentialist framework illuminates aspects of analytical approaches to the meaningful communication of concepts for pupil understanding of science. I bring the discussion to a close with a case study returning to topic materials in primary science and contemporary adaptations of MMF that seek to develop quality dialogue in the classroom (Tytler, Aranda, and Freitag-Amtmann, 2017). Without an appreciation of inferentialist lessons, classroom talk research, pedagogic practices, and teacher development may remain limited in developing meaningful communication of science in primary classrooms.

7.1 Meaning-Making Framework as Discourse Analytic Tool

As I continue to focus on the classroom dialogue on 'forces', reported by Scott and Ametller (2007, also see Chapters Two and Six), I return to consider Mortimer and Scott's sociocultural approach to the analysis of classroom discourse and communication of science concepts. The central concern of the present chapter is to critically review their claims regarding the analytic power of their framework (MMF) and the insights and assistance it offers teachers, given the scorekeeping approach and the inferentialist insight presented in the previous chapter. The main point was that discourse is not only linguistic performances or pragmatic moves but requires recognition of the interlocutors as minded beings, aware of others as equally minded. In discursive practice, we constantly make judgments and adjust our claims and beliefs (commitments and entitlements) concerning what has been said and what one presupposes and takes others to presuppose (scorekeeping). I begin by briefly recapitulating the meaning-making framework (abbreviated to MMF) and its approach to analysing the teacher-pupil dialogue in science classrooms. I review its application to the forces dialogue.

A vital contribution of the framework lies in bringing sociocultural theory to bear on practical classroom issues that face teachers on a day-to-day basis (Mortimer and Scott, 2003). Their classroom discourse analysis highlights particular ways in which 'different kinds of interactions between teachers and students…contribute to meaning-making and learning.' (ibid*.,* p. 5). Derived from empirical classroom observation, their framework serves as an analytic tool for examining and characterising critical features of classroom talk in science lessons, as discussed, and illustrated in Chapters Two and Three. As such, their framework allows teachers to reflect on their practice and gain insight into classroom talk central to their trade. Teachers' approach to communicating science concepts with children in science lessons sits at the very heart of MMF. Mortimer and Scott employ their *communicative approaches* analysis to analyse classroom discourse.

Scott and Ametller's study focuses on two key aspects[84] of their five-fold multi-levelled MMF framework: patterns *of discourse* and *communicative approach*. I discuss both components below to illustrate their analysis of classroom interaction and communication (i.e., discourse). I first address the *patterns of discourse* aspect of the framework, which involves examining the transcript or dialogue to identify 'a distinctive *pattern* of interaction in the talk' (Mortimer and Scott, 2003*,* p. 40 *italics*

[84] This is a legitimate use of the framework and the two aspects selected are the most central to analysing the classroom talk. The other aspects attend to teacher focus and intervention, and there are research studies where Mortimer and Scott have been selective of the aspect, they chose in order to make specific claims or analyses. However, the core contribution is always derived from their communicative approach (CA) analysis.

added). In the present case, the teacher's (Mrs Simon) interactions with her class as she works towards developing the idea of 'forces from a scientific perspective, through a whole-class discussion'. I provide a diagram that provides an at-a-glance summary analysis of the forces dialogue (see Fig. 17. Below). I then give a commentary on their approach to analysing classroom discourse.

7.1.1 MMF Analysis: At a glance

Transcript	Patterns of Discourse Analysis	Communicative Approach Analysis
1. Mrs Simon: *You had a good go at thinking about forces. Just to remind you of what you – or you to remind me of what you got up to last week – what are forces?* [Several pupils put up their hands and teacher nominates Jessica to answer.]	1. Initiation	**Episode 4a** Interactive / authoritative
2. Jessica: *A push or a pull?*	2. Response	
3. Mrs Simon: *Yeah! Pushes and pulls ... and forces, we, I'll just summarise what we did last week actually. Forces are needed to start things moving. Think about the things we did out in the yard. What else might they be used for?*	3. Evaluation/Initiation	
4. Becky: *Stop things moving.*	4. Response	
5. Mrs Simon: *Stop things moving. Can you think of any time when they stopped things moving? Give me an example of something that stopped ... something else moving ... last week?*	5. Evaluation/Initiation	
6. Lyndon: *A cricket bat stopped the ball.*	6. Response	
7. Mrs Simon: *The bat stopped the ball. And what else did forces do? In some of the activities? In this one* [pointing again at Lyndon to refer to the cricket bat]. *Mark?*	7. Evaluation/Initiation	
8. Mark: *The bat pushed the ball, once it stopped the ball it pushed it away.*	8. Response	
9. Mrs Simon: *How might you describe that? What did it do to the ball?*	9. Initiation	
10. Becky: *Maybe it stopped it and then it started it again.*	10. Response	
11. Mrs Simon: *Yeah! How?*	11. Evaluation/Initiation	
12. Connie: *Is it rebounding off it?*	12. Response	
13. Mrs Simon: *Kind of. How might we say that? How might we describe that movement? Ball comes from the bowler's hand to the bat ... what else is it doing to the ball?*	13. Evaluation/Initiation	
14. Alex: *Bouncing?*	14. Response	
15. Mrs Simon: *Hmm ... Yeah! Yeah! What ... how can we ... how else might we describe that?*	15. Evaluation/Initiation	
16. Lyndon: *It pushed it. It pushed the ball.*	16. Response	
17. Mrs Simon: *It pushed it from the bowler, didn't it? How did it change, once it's been stopped?*	17. Evaluation/Initiation	
18. Becky: *Direction.*	18. Response	**Episode 4b** Non-interactive / authoritative
19. Mrs Simon: *It changed direction, didn't it? And at the end of last week we talked about measuring forces, how we might sometimes need to measure a force, and how we might sometimes need to consider the direction of a force. And I want to go on today to look a little bit more about directions of forces and also measurements of forces, and ... thinking all the time ... What forces are in action? What's happening here? What's making*	19. Evaluation	

Fig. 17. MMF Analysis at a glance

7.1.2 Patterns of Discourse Approach to Analysis

The '*patterns of discourse*' analysis is derived from the work of American sociologist Hugh Mehan (1979), who researched classroom interactions. His study involved characterising the features of our conversations by categorising each *turn* in the conversation. These categories consist of *initiation*, *response* and *evaluation*, which are abbreviated to the letters, I, R and E:

- Initiation ('I') would normally be questions raised by the teacher.
- Response ('R'), the '*response'* uttered by the pupil.
- Evaluation ('E') would be offered by the teacher.

These labels (I-R-E) allow each *turn* in the conversation (*turns* have been numerically represented on the left-hand side of the transcript) to be coded, resulting in a *pattern* within the discourse. Below is an illustration of the '*patterns of discourse'* approach.

1.	Mrs. Simon: ... what are forces? Jessica.	**I**nitiation
2.	Jessica: A push or a pull?	**R**esponse
3.	Mrs. Simon: Yeah! Pushes and pulls ...	**E**valuation
4.	Mrs. Simon: Forces are needed to start things moving ... What else might they be used for?	**I**nitiation
5.	Becky: Stop things moving.	**R**esponse
6.	Mrs. Simon: Stop things moving [nodding head].	**E**valuation

From this analysis, a 'pattern of three' emerges, where a repeated cycle of I-R-E becomes visible from the dialogue. This 'I-R-E' pattern continues in subsequent turns, referred to as the *triadic dialogue* pattern and is considered a regular feature of teacher-pupil interactions in classrooms. In this teaching episode, Mrs Simon has a particular set of ideas that she wants to hear or the children to come up with or say. The key scientific idea she has in mind is that forces are not only 'pushes and pulls'. Forces are to be understood as also acting to 'start, stop and change direction' (Scott and Ametller, 2007, p. 81). In this concluding episode of the teaching sequence, Mrs Simon is 'not seeking points of view but focusing solely on the scientific story' (ibid.). In the dialogue, when she is not satisfied, she moves on to the next question and continues. In *patterns of discourse* terms, she *initiates* a new line of questioning, working her way towards her intended idea or set of ideas. The episode ends with Mrs Simon, Turn 19, where she *evaluates* the pupil's (Becky's) *response* as correct and moves on to review the purpose of the last week's lesson and then looks ahead to consider what they will do next. In sum, the discourse pattern provides a *representation* of the discursive interaction between teacher and pupils in classroom talk. There is no direct interactive exchange with the children in situations where only the teacher speaks. For example, in a lecture-style situation, in such cases, there would be no discourse pattern since there would be no interaction or turn-taking with pupils. Thus, the pattern of discourse approach also provides a *representation* of the level or extent of interaction between the teacher and pupil. The patterns identify whether episodes are *interactive* (typically IRE) or *non-interactive* (no patterns).

Turn 1-6: The analysis makes visible the I-R-E cycle. It exemplifies the *triadic dialogue* pattern.

Turn 7-18: This triadic pattern continues, and the IRE cycle becomes even more pronounced, as Mrs Simon presses her pupils to say what she is intent on teaching, that is, to talk or describe the bat and ball situation in a more scientific way. The answer she seeks and the ways of describing the situation she has in mind involves moving the children beyond just viewing forces being simply 'a push or a pull' but to be able to say and understand something about how 'forces can also produce a change in directions'. As the IRE cycle continues through this episode, in turn 18, Becky finally responds with the desired word, 'direction'.

Turn 19: Non-interactive or no discourse patterns, as Mrs Simon provides a final evaluation, confirming Becky's answer as correct as she referenced direction, by repeating and clarifying her one-word response, 'It changed direction, didn't it?'. She then proceeds in a presentational style, talking to the class, reviewing the progress of last week's activities, drawing on the present discussion and linking it to what they will be doing next, where she stresses the key scientific idea at the heart of the current episode, namely that forces act to start, stop *and change direction.*

Patterns of Discourse Analysis: Tabulated Summary

I have presented a summary of the patterns of discourse analysis in a tabulated form below. Next, I discuss Mortimer and Scott's *communicative approaches analysis*, which forms the central component of their meaning-making framework (MMF).

Episode 4. What are forces?

Patterns of Discourse	(a) Turn 1-18	(a) I-R-E
	(b) Turn 19	(b) No interaction

Table 17. Patterns of Discourse Analysis Summary

7.1.3 Communicative Approach Analysis

The communicative approach analysis 'lies at the heart of the framework' (Mortimer and Scott, 2003, p. 27). The *patterns of discourse* analysis constitute one aspect of the meaning-making framework (see Chapter Two, §2.2.2, pp. 41-45), which focuses on the forms of linguistic practices or classroom talk, drawing on turn-taking or 'speech acts' in dialogue as the unit of analysis. The *communicative approach* (CA) analysis, on the other hand, complements and extends the insights gained from the *patterns of discourse* approach. While the patterns of discourse analysis focus on turns and utterances, Mehan (1979) identifies how their roots lie within speech act theory. In referring to 'certain speech act theorists (Searle, 1976; Sinclair and Coulthard, 1975),' he explains how they consider 'the meaning of an utterance is determined by its illocutionary and perlocutionary force, not its grammatical features. And they maintain that this information is to be found within the internal structure of a given speech act.' (p. 63). The implication, which Mehan takes issue with, is the view 'that speech acts are complete in themselves; that one need not look beyond the boundaries of the speech act to determine its meaning.' (Ibid.). Mehan explicitly rejects this claiming that:

> The meaning of a given speech act is not contained within its internal structure. Instead, meaning resides in the reflexive assembly of initiation, reply, and evaluation acts into interactional sequences. (1979, p. 64).

This idea forms the basis of the IRE patterns and paves the way for patterns of discourse analysis. While Austin and Searle set up the theoretical foundations of speech acts, Mehan acknowledges how 'Sinclair and Coulthard were among the first to apply speech-act theory systematically to the study of discourse in an institutional setting.' (Mehan, 1979, p. 183). He goes on to claim that '[t]he major speech acts they identified in the classroom served as conceptual heuristics for this study.' and it was their insights and influence that led Mehan to 'characterize the sequential organization of classroom discourse as variations of ordered triples' (ibid., p. 183). This characterisation laid the foundations for Mortimer and Scott's patterns of discourse analysis.

While Mehan makes no direct reference to Vygotsky at these early stages of development within the field of classroom talk research and analysis, he nevertheless references several authors who can be related to Vygotsky and inferentialism, such as Herbert Mead, Michael Cole and David Lewis. The communicative approach analysis seeks to bridge aspects of teaching focus, relating to the scientific content and story with the teaching realities and practice in classroom talk. The CA combines the formal speech act and utterances aspect of discourse (e.g., patterns of discourse) with the pragmatics of science classroom discourse as a movement between everyday and scientific language (e.g., authoritative and dialogic discourse).

Mortimer and Scott go on to modify Mehan's *discourse patterns,* extending the IRE analysis by introducing an additional variant 'F' for feedback to the available categories. This *feedback* category identifies those instances where the teacher encourages and supports pupils to develop their point of view further by elaborating on pupils' responses prompting probing children response, as opposed to an evaluation that closes down any further discussion or interaction. The resultant discourse pattern is as an I-R-F pattern. In contrast to closed cycles of IRE, the IRF allows for the analysis to identify dialogue that are more open-ended and sustained chains of interactions, which offers far more flexibility in analysing classroom discourse. Introducing this new feedback code extends discourse patterns where not only are triadic cycles identified but dialogic chains such as I-R-F-R-F-R-F. Such patterns are typical of interactions where the teacher engages with the children in a more sustained and *dialogic* manner, exploring and probing their ideas and points of view (Mortimer and Scott, 2003). In developing the patterns of discourse analysis, their approach not only identifies linguistic patterns but serves to differentiate between *dialogic* and *authoritative* approaches to classroom talk, which underpins Mortimer and Scott's Communicative Approaches (CA) analysis. The *communicative approach* emphasises the approach to classroom interaction the teacher chooses to adopt. The *communicative approach* analysis aims to capture and characterise changes and development in classroom interactions in a specific episode or over an entire teaching sequence. The teacher's approach to classroom talk shifts and changes in seeking to establish a meaningful understanding of scientific concepts with the children. There are two dimensions of classroom talk that the communicative approach (abbreviated to CA) identifies:

- Interactive/Non-interactive, which concerns the number of participants involved in the interaction
- Dialogic/Authoritative, which concerns the range of ideas or points of view involved in the discursive communication

I have already discussed these dimensions in Chapter Two. In this chapter, however, I am concerned with exploring the methodological issues that underpin this approach. In combination, these two dimensions generate the four classes of the communicative approaches analysis of classroom talk. In order words, there are four ways to describe how a teacher might communicate with pupils in the classroom. The four classes can be briefly characterised as follows:

Classes of Communicative Approaches

A	Interactive/dialogic	Teacher and pupils consider a range of ideas.	(I/D)
B	Non-interactive/dialogic	Teacher reviews different points of view.	(NI/D)
C	Interactive/authoritative	Teacher focuses on one specific point of view and leads pupils through a question-and-answer routine with the aim of establishing and consolidating that point of view.	(I/A)
D	Non-interactive/authoritative	Teacher reviews different points of view.	(NI/A)

Table 19. Classes of communicative approaches

The CA analysis identifies two forms of communicative approaches in the dialogue on forces. **Turn 1-18** (*see Fig. 17,* p. 231; Table 19., p. 238*)*: On the interactive/non-interactive dimension, the IRE discourse patterns indicate that the approach adopted by the teacher during these turns is *interactive*. These turns see the teacher focus on establishing a scientific point of view, particularly the idea that forces are not only ‘pushes’ and ‘pulls’ but also involve acting to start, stop and change directions of objects in motion. Thus, regarding the dialogic/authoritative dimension, the diversity of ideas that guides the talk and focus on the scientific view alone indicates an authoritative approach. The *interactive* exchange the teacher adopts is considered to be *authoritative* in approach. Mortimer and Scott claim that most *authoritative* interactions are played out through the IRE form of interaction (2003). In sum, turns 1-18 are classed as Interactive/Authoritative on the communicative approach.

Turn 19 (see *Fig. 17,* p. 231; Table 19., p. 238): This turn sees the teacher provide an evaluation that leads into an extended monologue. Subsequently, there are no discourse patterns, which indicates that this exchange is *non-interactive.* The teacher at this stage is focused on summarising and addressing the key scientific points, given the content of lessons that follow. On the dialogic/authoritative dimension, the communicative approach, focusing on a specific set of ideas related to the scientific point of view, illustrates how the teacher adopts an *authoritative approach.* Therefore, Turn 19 is classed as a *Non-interactive/Authoritative approach*.

In sum, the communicative approach analysis identifies a shift in teaching in this single episode. Initially adopting an *interactive/authoritative approach*, at the final stages, the teacher can be seen to shift towards what has been identified as a *non-interactive /authoritative approach*. Although this analysis may be applied to the entire teaching sequence (see Chapter Two), I aim to merely illustrate the MMF approach to discourse analysis. The analysis shows how the teacher from turns 1-18 adopts an *interactive approach* in talking with the children about forces, as the teacher works toward what she has in her own mind, her learning intention, focusing on the scientific point of view. Scott and Ametller (2007) highlight how Mortimer and Scott's analysis of classroom discourse makes visible their central claim that science teaching involves 'introducing pupils to the ways of talking and thinking of the scientific community' (p. 77). In working towards her own intention, authoritative in nature, she illustrates how 'meaningful learning of science involves both 'opening up' (dialogic) and 'closing down' (authoritative) approaches to teaching' (ibid.). I have presented a summary of the communicative approach and patterns of discourse analyses in a tabulated form below (Table 20.).

Communicative Approach Analysis: Tabulated Summary

Episode 4. What are forces?

	Patterns of Discourse	**Communicative Approach**
(a) Turn 1-18	(a) I-R-E	(a) Interactive/ authoritative
(b) Turn 19	(b) No interaction	(b) Non-interactive/authoritative

Table 20. Summary of Communicative Approaches Analysis

I provide a visual comparative summary of both analytic approaches at glance, juxtaposed with the transcript in the section below.

7.2 Pragmatics of Discourse: A Critical Comparison

In the previous chapter, I introduced the deontic scorekeeping approach and its application to analysing the dialogue. In discussing the MMF approach to discourse analysis above, I have highlighted key methodological aspects of their analytic framework. With the distinction between linguistic and normative pragmatics in mind, I critically and comparatively discuss these two analytical orientations below. To set the context for this discussion, I provide a side-by-side analytic summary of the 'forces' dialogue.

7.2.1 Comparative Summary of MMF and DSK

Analyses of Discourse At A Glance

	Representation of Discourse		**Inferential Role of Force Concept**	
Claims	Patterns of Discourse	Communicative Approach	Teacher Entitlements	Teacher Commitments
1. **Mrs. Simon:** You had a good go at thinking about forces. Just to remind you of what you – or you to remind me of what you got up to last week – what are forces? [Several pupils put up their hands and teacher nominates Jessica to answer.]	Initiation (I)	Episode 4a: Interactive/ dialogic		(C1) Forces
2. **Jessica:** A push or a pull?	Response (R)			
3. **Mrs. Simon:** Yeah! Pushes and pulls ... and forces, we, I'll just summarise what we did last week actually. Forces are needed to start things moving. Think about the things we did out in the yard. What else might they be used for?	Evaluation (E) Initiation (I)		(E2) Forces are pushes and pulls	(C3) Forces are needs to *start* things *moving*
4. **Becky:** Stop things moving.	R			
5. **Mrs. Simon:** Stop things moving. Can you think of any time when they stopped things moving? Give me an example of something that stopped ... something else moving ... last week?	E I		(E4) Forces are needed to *stop* things *moving.*	
6. **Lyndon:** A cricket bat stopped the ball.	R			
7. **Mrs. Simon:** The bat stopped the ball. And what else did forces do? In some of the activities? In this one [pointing again at Lyndon to refer to the cricket bat]. Mark?	E I		(E5) The bat stopped the ball.	

8. **Mark:** The bat pushed the ball, once it stopped the ball it pushed it away.	R			
9. **Mrs. Simon:** How might you describe that? What did it do to the ball?	I		(E6) Entitlement not acknowledge d	
10. **Becky:** Maybe it stopped it and then it started it again.	R			
11. **Mrs. Simon:** Yeah! How?	E I		(E7) Bat stopped it (ball) and started it again.	
12. **Connie:** Is it rebounding off it?	R			
13. **Mrs. Simon:** Kind of. How might we say that? How might we describe that movement? Ball comes from the bowler's hand to the bat ... what else is it doing to the ball?	E I		(E8) It (ball) is rebounding off it (bat)	(C9) *Movement* unacknowledg ed: Bat-Ball starting, stopping is a movement
14. **Alex:** Bouncing?	R	Episode 4a: Interactive/ dialogic		
15. **Mrs. Simon:** Hmm ... Yeah! Yeah! What ... how can we ... how else might we describe that?	E I		(E10) Bouncing is a movement	
16. **Lyndon:** It pushed it. It pushed the ball.	R			
17. **Mrs. Simon:** It pushed it from the bowler, didn't it? How did it change, once it's been stopped?	E I		(E11) It (bat) pushed the ball	(C12) Movement *changed*
18. **Becky:** Direction.	R			
19. **Mrs. Simon:** It changed direction, didn't it? And at the end of last week we talked about measuring forces, how we might sometimes need to measure a force, and how we might sometimes need to consider the direction of a force. And I want to go on today to look a little bit more about	E	Episode 4b: Non-Interactive / authoritative	(E13) Direction Unacknowled ged: the change in movement is due to forces acting on the motion of the ball by the ball.	

directions of forces and also measurements of forces, and ... thinking all the time ... What forces are in action? What's happening here? What's making				

Table 18. Comparative analyses at a glance

7.2.2 Scorekeeping Analysis: A Critical Discussion

Their communicative approach is at the heart of Mortimer and Scott's discourse analytic framework (2003). Inspired by Wertsch's sociocultural theory (see Chapter Three), their analytic methodology is firmly rooted in Wertsch's pragmatics.

In developing his sociocultural theory, Wertsch views discourse through a Bakhtinian lens and takes *utterances* as the minimal unit of analysis in our communicative practices, which manifests and underpins the communicative approach (CA). Mortimer and Scott's analysis of classroom discourse focuses on linguistic performance, or *speech acts*, which attends to language-use structures, such as turn-taking of the *patterns of discourse analysis.* Concentrating on Wertsch's pragmatics, their 'analysis focuses on the patterns of teacher and student utterances in the flow of the discourse; it is concerned with characterizing the typical patterns of interaction or speech genres which constitute the discourse'[85] (Mortimer and Scott, 2000). The CA, on the one hand, proceeds by identifying discourse patterns in terms of the turn-taking practices. On the other hand, this analysis proceeds by differentiating between the authoritative and dialogic dimensions of communicative interactions by categorising classroom discourse into one of four classes. The classificatory nature of the communicative approach is crucial in making classroom talk visible (Chapter Three). Both *patterns of discourse* and *communicative*

[85] Before the full-fledged MMF, their analytic approach was initially referred to as the *flow of discourse* (Mortimer and Scott, 2000) and later developed into their *communicative approaches* analysis (CA).

approaches analyses that constitute the analytic power of MMF are classificatory approaches to discursive practices in terms of linguistic utterances. The meaning-making framework makes visible the invisible talk of the science classroom. It seeks to explain communicative and linguistic practices by appealing to forms of utterances and the structure of discourse flow to capture, characterise or *represent* social interactions and discourse in science classrooms, which they identify and refer to as 'meaning making'. This framework offers the teacher a tool to analyse, reflect and understand the development of science concepts through changes and development of the classroom discourse. So, what is so problematic about seeking and recognising patterns in providing representations?

Mortimer and Scott understand discursive practices in terms of language-use as determined by the circumstances under which a claim is made or uttered. Their discourse analytic framework focuses on linguistic practice confined to linguistic performances or linguistic pragmatics. Understanding the problem of representations in explaining meaningful communication, and meaning itself, requires coming to appreciate how Brandom's inferentialism serves as an alternative to representationalist explanatory strategies in issues of meaning and communication, which inspired Derry's inferentialist reading of Vygotsky. An essential inferentialist contribution lies in recognising our discursive practices as a distinctly human and rational practice, as a game we play, in *giving and asking for reasons*. Brandom's scorekeeping account of discursive practice not only captures the nature of inferential moves articulated by players in speech acts (deontic status) but also recognises players (deontic attitude) attitudes in making these moves and playing the game with others. In other words, viewing dialogue as a game played by players, as with a game of chess, the exchange not only involves practical moves but players and their rational judgments in playing a particular move by the rules of the game and in response to other players, involves an inferential move. Scorekeeping acknowledges players as both autonomous and responsive both to the rules of the game and to other players by attending to the inferential nature of what we humans *do* in making claims and the *normative* character of our concept-using practices. From this perspective, assertive practices are re-orientated and interpreted, not limited to linguistic performances but as tied up with players' mindedness and rational autonomy, reasons, inferentially articulated by moves in playing the game responsive to the rules and other players' moves. These rules or norms not only determine the correctnesses of what *is* said but also constrain what *ought* to be said. An inferentialist approach to linguistic practice recognises our discursive practices as fundamentally a normative affair. These inferentialist dimensions illuminate our understanding of the nature of classroom talk in science classrooms. They also highlight how representational approaches to analysing discourse by coding, categorising or classification remain limited. This limitation emerged as a theory-practice gap, tension or challenge in dialogic approaches, and teacher development discussed earlier (see Chapter Three §3.3). As representation by its very approach immediately divides, disconnects and dehumanises the relation between language, use and our concept-use as minded, rational free creatures bound by norm-governed practices, acting with and for reasons. As a normative affair, taken as fundamental and primitive, there is no need to relate the two separate poles of social language and individual mind or words and meanings. When our discursive practices are understood in terms of reasons and the inferential role concepts play in our rational and normative practices, then individual-social or word-meaning relations are understood as already always related by inferential relations.

Critical Review and Insights

A fundamental issue that animates Brandom's move towards inferentialist semantics and normative pragmatics is the problematic nature of classification. The critical problem he takes with the representationalist paradigm in explaining meaning and communication, such as naming, labelling, referring or classifying, is that such representations fail to account for the distinctive nature of us humans as concept-using creatures engaged in rational judgments in discursive practices. In taking issue with classification in an explanatory account of meaning and concept-using practices, paradigmatically discursive practices, Brandom states:

> Classification by the exercise of regular differential responsive dispositions may be a necessary condition of concept use, but it is clearly not a sufficient one. Such classification may underlie the use of concepts, but it cannot by itself constitute discursiveness. (1994, p. 87)

Brandom does not dismiss the role of classification out of hand. His central argument is that classifications are not by themselves meaningful. Being able to classify, sort, label, or name correctly does not reveal the conceptual content or meaning expressed in the practical activity. This applies methodologically in identifying or naming discursive moves or communication approaches. Being able to represent discursive practices and make them visible does not make them explicit for us humans who are responsive to other concept-using beings in giving and asking for reasons. The classification as sorting instances or items into general kinds, although maybe repeatable and thus reliable, this 'reliable differential responsive disposition' does not confer meaning or inferential reasons that animate such moves or responses in our discursive practice as the game of giving and asking for reasons. In analysing discourse to understand the meaningfulness of communication, we need tools that offer more than representations. An approach not only needs to make practices visible but should make explicit specific inferential patterns, logical structures expressed in our normative practices in thinking, saying and doing certain activities. As expressed by Brandom himself when he raises the question:

> What else must be added to responsive classification to get to an activity recognizable as the application of concepts? What else must an organism be able to do, what else must be true of it, for performances that it is differentially disposed to produce responsively to count as applications of concepts to the stimuli that evoke those responses? One dimension of a reply was indicated in the previous chapter-a normative dimension is required, which can underwrite a distinction between correct and incorrect applications of concepts. But many things can be done correctly or incorrectly. The question being asked now is what it is for what is subject to such assessment to be concept use (rather than, say, hammer use, or tool use). (1994*,* p. 87)

On an inferentialist account, relying on representations, classification or namings does not support coming to a meaningful understanding of our discursive practices.

> …the difference between merely *responsive* classification and *conceptual* classification is their mastery of the practices of giving and asking for *reasons,* in which their responses can play a role as *justifying* beliefs and claims. To grasp or understand a concept is, according to Sellars, to have practical mastery over the *inferences* it is involved in-to know, in the practical sense of being able to distinguish, what follows from the applicability of a concept, and what it follows from. (1994*,* p. 89)

Essentially, an inferentialist interpretation of our discursive practices is not merely linguistic but deontic practices. In short, the analytic act of classifying discourse types makes discursive structures visible but fails to make explicit the inferential commitments that animate the discourse and utterances articulated by us players in giving and asking for *reasons*. In thinking about the meaning of names, labels or classes, Brandom claims:

> What makes a classification deserve to be called *conceptual* classification is its *inferential* role. It is practical mastery of the inferential involvements of a response, the responder's understanding it in this sense, that makes the response an intentional state or performance—one having a content for the one whose state or performance it is, and not merely for those using it as an indicator. (1994, p. 89)

Herein lies the distinction between linguistic performance and rational activity, rational judgments and normative assessments in making moves in dialogue in responding to others in deontic practice. We track and trace every commitment and entitlement for ourselves and others, holding each other accountable to the rules of the game we play. In explaining how his inferential semantics relates to this normative account of discursive practices, Brandom claims that 'semantics must answer to pragmatics':

> Since semantics must in this way answer to pragmatics, the category of sentences has a certain kind of explanatory priority over subsentential categories of expression, such as singular terms and predicates. For sentences are the kind of expression whose free-standing utterance (that is,

> whose utterance unembedded in the utterance of some larger expression containing it) has the pragmatic significance of performing a speech act. Declarative sentences are those whose utterance typically has the significance of an assertion, of making a claim. (2001, p. 125)

Understanding the nature of such practices requires a normative perspective that privileges our rational judgments by engaging, challenging and endorsing judgments in a practice-based approach. Subsequently, the limitation of the representational approach is made explicit by recognising our discursive moves as involving normative assessments relative to each player and the score as being socially perspectival. In coming to understand the concept force in classroom discussions, according to Brandom such exchanges are viewed as ‘the sort of social-perspectival, dialogical inferential articulation that makes possible the objectivity of conceptual content’ (2001, p. 37). So, while the representational or dialogic dimension is not rejected outright, an inferentialist re-orientation to analysis begins by privileging the inferential and normative dimensions.

The scorekeeping approach stands in contrast to discourse analytic approaches. The MMF’s communicative approach analysis focuses on linguistic features, coding forms utterances, identifying discourse patterns and moves and classifying discourse, which constitutes a representational approach. From an inferentialist perspective, such patterns do not make explicit the responsibility and judgments of players in playing the game and responding to moves. A focus on making linguistic features of classroom talk visible neglects players' autonomy and their judgements in playing the game governed by rules. I contrast these two approaches to theorising and analysing classroom discourse by summarising the paradigmatic differences that manifest across these two perspectives.

Contrasting Approaches to Interpreting and Analysing Discourse

Representationalist Paradigm: **Linguistic Pragmatics**	**Inferentialist Paradigm:** **Normative Pragmatics**
Language-Use	Game of Giving and Asking for Reasons
Turn-taking	Player Moves
Speech Acts	Type of Move by Player
Utterances serve as the '*real unit* of speech communication' (Wertsch, 1991, p. 50).	Assertions, players Inferential Move
	Deontic Scorekeeping Practice
	Deontic Status (Normative Status) is achieved by making a move in the game, which as expression of a player's inferential move *Deontic Attitude* (Normative Attitude): Normative Attitudes to inferential moves For Brandom, the 'minimal unit of *responsibility* is the judgment.' (Brandom, 2011, p3).

Table 22. Contrasting different analytical orientations

An inferentialist orientation to discursive practices views language as a *game* involving *players* in *giving and asking for reasons* and recognising such practices as intersubjective communication with other minded, rational and concept-using creatures, involving the articulation of our reasoning. What is lost on linguistic accounts is an acknowledgement of our distinctive discursive rationality as players in this distinctive human game. The representationalist nature of discourse analytic frameworks, such as MMF, dehumanises the nature of our discursive practices, divorcing thought from talk, or reasons from speech, while neglecting the norm-governed character endemic to our social practices. It is rather like giving an account of playing chess and negating the players and game-playing strategies and responses to other players to focus on the pieces and moves confined to the chess board. In other words, our linguistic performances in being reduced or reducible, even in principle, to linguistic units disenchant the central features of human discursive practices: reasons and norms.

The representationalist approaches in this sense are essentially a third-person perspective, a view from nowhere, so to speak, and as such sits in opposition to the inferentialist paradigm that privileges the first-personal judgments and reasons that every player is responsive to in every move that is a response to some other player. A player's move changes the game's score and is to be tracked and traced by each player. As illustrated in my scorekeeping analysis, each player serving as a scorekeeper, in every move and at every stage of the game, not only responds to a linguistic utterance but to inferential moves of an assertion. The player tracks for oneself and attributes to others not just given a single move but as related to all other claims made thus far in the game looking upstream and to potential moves looking downstream.

The analysis of discursive practices, viewed through Brandom’s normative pragmatic lens as deontic scorekeeping practices, sits in contrast to the one-shot coding of discourse analysis. This normative pragmatic approach derived from an inferential orientation to our concept-using practices cannot be captured by a representational orientation that undertakes explanation by appealing to coding or classifying discourse and its social and circumstantial context, which are viewed either self-explanatory patterns or deferred to teachers as tools for self-reflection. The central lesson from the scorekeeping approach highlights how representational strategies neglect the dynamics of judgments and autonomy articulated by the multifarious attitudes and statuses made visible at any given stage in the game and made explicit in practice or by an interpretative scorekeeping approach. On the other hand, the critical inferentialist lesson is the central role of normativity in a practice-based approach to scorekeeping, which involves players calibrating their commitments and entitlement from a first-personal perspective in playing the game. What does become apparent is the fundamental role of the inferential structure of concepts in a knowledge domain and the normativity of their use in discursive practice, which teachers are required to master if they are to be responsive not only to discursive practices in science lessons, but claims articulated by their pupils.

7.3 Quality Teaching in Primary Science: The Case of Materials

In this section, I aim to move the illustrative arguments presented above and in the previous chapter to address the influence of MMF in contemporary research in primary science education and quality teaching in classrooms (Hackling, Ramseger, Chen, 2016). I present a short case study on the topic of materials that illustrates how the inferentialist challenge to analytical and methodological issues reaches beyond the meaning-making framework.

7.3.1 An Illustrative Case Study: The Discursive Moves Framework

As an exemplar of classroom research in primary science classrooms, I look to the EQUALPRIME Project[86], led by Russell Tytler and colleagues, focusing on quality teaching (Clarke, 2017). Tytler has written extensively on primary science, focusing on the scientific concepts of materials, properties and their changes[87] (Tytler and Peterson, 2003, 2005; Tytler, 2000). Of significant interest here is their focus on the

[86] An international project involving diverse cultural settings and teachers from Australia, Germany and Taiwan

[87] Tytler and colleagues, not only follow in line with dialogic approach as illustrated here, but their work places a strong emphasis on representations. Due to the limitations of space this is a discussion that will need to be pursued elsewhere.

orchestration of classroom discourse, which builds on Mortimer and Scott's meaning-making framework and their dialogic-authoritative distinction (Tytler, Aranda and Freitag-Amtmann, 2017). Tytler and colleagues aim to 'identify discursive moves and patterns that are associated with teacher expertise…, and in particular to codify these moves in ways that can inform the professional learning of teachers of science.' (ibid., pp. 123-4). In formulating their *discursive moves* framework, they acknowledge components from other classroom discourse analytic approaches (Edward and Mercer, 1987; Mercer, 2004; Lemke, 1990; Scott, 1998; Mortimer and Scott, 2000; Mortimer and Scott, 2003). Their adapted discourse analytic framework describes 'effective orchestration of these moves' drawing on the authoritative-dialogic distinction. They aim to provide a 'sharper, evidence based description of the discursive moves that expert teachers make, within a coherent framework of broader purposes, with the intention of using this to support teacher learning.' (Tytler. et al., p. 125). Characterising quality teaching and expert practices, they claim '[w]e used a discourse analytic methodology (Johnstone, 2002) to unpack the meaning/intent of the teachers' discursive moves'. (p. 126). This analytic approach follows an iterative coding approach that involves analysing 'the nature and intent of teacher responses to student input', where 'all teacher utterances… would fit within the coding system' (ibid., p. 127). Their framework provides an ideal example of a discourse analytic approach to classroom research and teacher development in primary science. In the remaining sections, I illustrate how such methodological approaches remain prone to the inferentialist challenge and fall prey to or 'remain within' the representational paradigm (Derry, 2013a, p. 36).

Discursive Moves Framework: Analytic Illustration and Key Insights

In discussing 'orchestrating classroom discourse', I focus on their report on an award-winning specialist teacher of primary science, Mr Collins from Australia. The teaching episode focuses on investigating material properties within the solids, liquids and gases framework, which mirrors issues discussed earlier (see Chapter Five). The brief dialogue extract explores children's ideas of a 'solid'. Having discussed the definition of the solid state, the teacher capitalises on a child's idea that he can actively challenge with a demonstration.

Dialogue and Coding Discursive Moves

T: If you're saying something's hard. What about paper? Is paper a solid?	Challenging directly
S: [Various answers]	
T: No? Ah. I'm not telling you one way or another. I want you to tell me	Eliciting further responses
S: It's not a liquid. It's not runny…	
T: It's not runny	Marking
S: You can't put your hand through it like a gas. Because you can put your hand through a gas	**
S: You can't just put your hand through a solid. You can't just put your hand through a brick, so that is a solid. [Teacher leaves room for a brief moment returning with a page of a newspaper]	
T: Hold that. Hold it. [Student holds paper as teacher puts his hand through the piece of paper]	[Not coded]
T: I can put my hand through that. Does that make it not a solid?	Challenging directly

Fig. 18. Coding dialogue and discursive moves

As an analytic tool, the framework codes each utterance made by the teacher in classroom dialogue. Seventeen categories code teacher discursive moves in responding directly to 'student input in interactive talk'. These codes were grouped under three broader classes, which 'reflect their wider purposes in relation to exploring and shaping student understandings.' (Tytler. et al., p. 127), namely, Eliciting, Clarifying and Extending. Two categories were coded separately as they fell outside the major categories. First was 'new questions', associated with initiating or opening up new lines of inquiry, where student responses diverge from ongoing interaction. The second was a closing category, associated with ‘Elaborating’ and presenting further on the scientific view’. These opening and closing categories served to bracket the three major groups. I summarily tabulated all five categories below (see Fig. 19).

Discursive Moves Coding Categories

New question	"This involves asking a new question, which begins a new line of inquiry or discussion. This is distinct from asking a related question aimed at extending student thinking around the same conceptual idea."
Eliciting/*acknowledging* student input	"These are teacher moves that elicit and acknowledge student inputs and establish them as contributions that are valued in building understanding in the classroom. These moves include canvasing of further ideas, and responses to input that vary from simple recognition of student contributions, to marking out contributions for special attention. They include positive evaluations and negative evaluations (for these teachers this latter was uncommon). They are used when the teacher is encouraging and gathering responses to an initial question, to get ideas ‘on the table’. *The order of the sub categories reflects increasing shaping of students’ responses.*"
Clarifying	"These are a set of response moves aimed at clarifying and sharpening the student input to achieve greater precision of meaning. These involve discursive devices that shift the language of student input to more scientific ways of talking about the phenomenon, from simply asking for students to be clearer about what they are saying, to re-voicing the input to subtly impose scientific language and perspectives. The order of the sub categories reflects increasing introduction of scientific language."
Extending student ideas.	"These moves aim to shift students’ ideas forward, by challenging students to extend or re-think their ideas or use them in another context. These are discursive moves that invite students to embellish and go beyond current ideas, to justify their claims and to reason. This may involve a sequence of further, extending questions that progressively open out students’ thinking or it may involve requesting further opinion on students’ input.The order of the sub categories reflects increasing challenge to students to refine, re-think and extend their ideas."
Elaborating, presenting the scientific view	"A relatively extended response that relates to but moves beyond what a student said and presents and elaborates on new science ideas. It may be a summing up of the whole discussion and extending to new explanatory ideas. It may be an illustrative, explanatory story that builds on a student response. The key distinction between this and other categories is that the teacher input extends beyond the contributions of the students."

Fig. 19 Codes for discursive moves analysis

What is so problematic about this adapted analytic approach? I respond to this query by illustrating Tytler and colleagues' analytical categories and codes and subsequent analysis and insights. In reviewing their findings, I foreground the inferentialist lessons articulated above: our distinctive human practices as an expression of our ever-present discursive rationality continue to be overlooked, neglected and under-theorised by representational approaches.

Classroom Discourse and Teacher Scorekeeping

In this short dialogue, Mr. Collins discusses materials with pupils employing the distinction between solids, liquids, and gases, in line with my discussion in Chapter Five. In describing Mr. Collins's communicative approach in classroom talk, Tytler and colleagues claim that in exploring new ideas with his pupils 'he acknowledges their responses, but as their ideas develop, he focuses on shaping their language, re-voicing their responses towards a more scientific understanding of the topic.' (2016, p. 132). However, an inferentialist reorientation of interpersonal discourse requires attending to those aspects neglected by discourse analytic approaches, namely the inferential structure of concepts used (meaning) and the normative character of our discursive practices (communication). I have provided a side-by-side analytical summary between their discursive moves and a scorekeeping analysis of discursive practice below.

Discursive Moves and Deontic Scorekeeping: A side-by-side Summary of Analysis

#		Discursive Move	Player Moves	Teacher's norm-governed Inferential Moves
1	T: If you're saying something's hard. What about paper? Is paper a solid?	Challenging directly	Query: Challenging Commitment	Solids are Hard Paper is solid
2	S: [Various answers]			
3	T: No? Ah. I'm not telling you one way or another. I want you to tell me	Eliciting further responses	Query: Challenging Entitlement	
4	S: It's not a liquid. It's not runny...			Not Liquid Runny
5	T: It's not runny	Marking	Teacher Endorsement: Pupil gains Entitlement	Paper is not runny
6	S: You can't put your hand through it like a gas. Because you can put your hand through a gas	**		Penetration Gas
7	S: You can't just put your hand through a solid. You can't just put your hand through a brick, so that is a solid. [Teacher leaves room for a brief moment returning with a page of a newspaper]			Penetration Solid Brick
8	T: Hold that. Hold it. [Student holds paper as teacher puts his hand through the piece of paper]	[Not coded]	Undertaken Entitlement: Unacknowledged by pupils	Newspaper is a solid that you can put you hand through, given sufficient force.
9	T: I can put my hand through that. Does that make it not a solid?	Challenging directly	Assertional Commitment and Query: Challenging Entitlement	Paper Penetration

Table 23. Illustrative side-by-side comparison of analyses

Inferential Role of the Concept 'Solid'

Mr Collins as an expert teacher has a certain *practical mastery* of the logical relations that govern the use of the concept 'solid' and the inferential role the concept *ought* to play in thinking and talking science, which directs the ongoing discursive interaction. An expert teacher is aware that though the concepts 'hard' and 'solid' may seem straightforward, much more is involved in the concept's use and articulation than initially assumed by the teacher or pupils (see Chapter Five). In introducing the newspaper as a material (Turn 8), the teacher is aware of the inferential role 'solid' plays within the solids, liquids, and gases framework and the norms governing the discourse and consequential compatible and incompatible claims (See Chapter Five). His *responsiveness to reasons*, to the logical compatibility and incompatibility claims, allows him to assess pupil claims made in Turn 7 and respond in Turn 8 by selecting a material that challenges their inferential commitments. Challenging commitments without giving the answer away, engaging pupils in the *game of giving and asking for reasons* is also expressed in Turn 3. Thus, in Turn 9, as an inferential move and response, the teacher asserts, "I can put my hand through that [newspaper]"[88], acknowledging an entitlement some pupils may not have, amplifying their reasoning. According to an inferentialist interpretation, developing conceptual understanding is to become better at playing the game. In this sense, the discourse is not a matter of making legitimate discursive moves by using specific vocabulary but by participating in *the game of giving and asking for reasons* and mastering inferential moves by playing with awareness and responsiveness to the consequential-incompatibility relations governing the game or scientific claims. In

[88] Now, the issue of ambiguity and lack of precision in discursive practice discussed in the last chapter is illustrated here. However, rather than re-iterate the point I focus on addressing the methodological point regarding the analytic deficit of representational approaches.

sum, a normative pragmatic lesson is that the discursive moves and dialogic structures that Tytler and colleagues employ are not limited to linguistic practices but also related to the logical or inferential structures expressed within our assertional and deontic practices. From an Inferentialist perspective, the expert teacher is not only aware of the correct use of concepts or appropriate vocabulary but is constantly responsive to his pupils' inferential reasoning, articulated in claims related to background assumptions and potential consequences. This is not limited to utterances or language used, but their inferential reasoning, distributed across a network of claims within a norm-governed practice or logical space of reasons. The teacher understands the class dialogue as a *game of giving and asking for reasons*, governed by norms of inferences in discourse (logical space of reasons).

7.3.2 Teacher Development Revisited: Some Inferentialist Implications

The discursive moves framework and MMF utilise a discourse analytic approach to develop professional teaching practice. However, inferentialism illustrates how the classificatory approach or presentational paradigm limits the meaning-making framework. The critical insight the scorekeeping approach foregrounds is how the role of reasons and norms is already always in play in our discursive practices. Inferentialism in accounting for the first-personal dimension in describing our concept-using practices as rational and logical and analysing our discursive interaction as norm-governed and socially perspectival has implications for how we conceptualise, and approach thought and talk in the classroom (see Chapter Eight). In other words, reorienting meaning-making interactions in terms of inference-making reasoning articulated in claim-making practices, as part of the same process, requires teacher development to consider critical lessons of inferentialism in teaching and learning interactions in thought and talk of science classrooms.

In my initial review of MMF, I discussed emerging challenges to MMF and classroom talk more broadly. In reviewing emerging challenges facing MMF and dialogic teaching, I raised three central concerns: the stagnancy of dialogic and talk research, the quality of classroom talk and barriers to professional teacher development (see §3.3). To address the theory-practice divide and resolve subsequent challenges, we need an approach to understanding thought and talk that does not divide them in the first place. In other words, an approach that privileges inferential relations over representational ones. Scorekeeping practice reorients our understanding of the nature of concepts, concept use, and development. An appreciation of the nature of thought and talk requires grasping how representations fail to capture the first-personal perspective, a practical know-how, in the sense of knowing *why* or having reasons and understanding the rules of the game one is playing and getting better at playing it. The third-personal representations, meditational means, references or causal relations neglect these inferential dimensions. Any development by the teacher or the child involves not grasping how we talk in classrooms but coming to appreciate how this talk is socially-perspective. As such, in making inferences and in playing the game, what is crucial is not making visible doings or sayings but becoming responsive to reasons, the logical space of reasons in which one believes, says and does anything within the science classroom. As I attempt to flesh out the implications for primary teachers in teaching and talking science in primary classrooms, I dedicate the remaining chapters to illustrating what inference-making and claim-making practices involve for teachers in developing their practices.

7.4 Summary Remarks

The scorekeeping approach alerts us to another dimension in our discursive practices. The central argument is that making discursive practices visible still falls short of making explicit the reasons that animate our discursive moves. A crucial recognition is that players not only play the game but can get better at playing it. So, how can classroom research and pedagogic development proceed if not through new forms of classifying or representing discourse? The last four chapters have attempted to illustrate how and why inferentialism offers a more refined normative pragmatic account of our discursive practice. An inferentialist account of classroom discourse, rather than treating language as linguistic practices or performances, consider our practices as involving rational creatures, not just saying words but making rational judgments in mutually *giving and asking for reasons.* An inferential paradigm takes our reasoning as a fundamental starting point in an account of our thought and talk. This paradigmatic re-orientation of discursive practices subsequently sets up an alternative theoretical framework. In making the limitations of representationalist approaches explicit, it offers an alternative lens through which to interpret, describe and understand meaning-making in the classroom. This inferentialist framework offers theoretical and analytic insights into supporting teachers to develop an inferential orientation in classroom interactions and teaching practices.

8 An Inferentialist Re-conceptualisation of Science Learning and Teaching

A key concern for Mortimer and Scott in their science education and classrooms research has been conceptualising children's learning of science concepts (Scott, Asoko and Leach, 2007; Mortimer and Scott, 2003; Mortimer and El Hani, 2014). A crucial part of their project has been theorising the development of concept meanings in teaching and learning science. In Chapter Three, I illustrated their framework as an operationalisation of Wertsch's post-Vygotskian sociocultural theory of mind and meaning in science classrooms, situated within a post-constructivist paradigm. In Chapter Four, I presented their view in contrast to Derry's philosophical critique of post-Vygotskian scholarship. Having introduced Brandom's inferential semantics in Chapter Five and illustrated his normative pragmatics and vocabulary in Chapters Six and Seven. I attempted to show how Derry's Vygotsky scholarship relates to and reorientates the meaning and communication of science concepts in primary classrooms. This chapter summarises how different aspects of Brandom's inferentialism offer an alternative epistemological orientation in relation to Vygotsky's contribution to learning theory and educational issues. Inferentialism is presented as an alternative to the representational approaches to theorising concepts, meaning and communication. I take Mortimer and Scott's meaning-making framework as an exemplar, which serves to illuminate some long-standing theoretical issues in conceptualising classroom talk and meaning-making research. To better understand the implications of inferentialist insights, I turn to address the nature of these theoretical issues, namely the dichotomy in the metaphors of learning (Sfard, 1998; Scott, Asoko and Leach, 2007) and subsequent tensions between dialogic and authoritative forms of classroom discourse (Scott, Mortimer and Aguiar, 2006).

8.1 Conceptualising Science Learning: Straddling Two Metaphors

In their years of classroom research, a central concern for Mortimer and Scott has been conceptualising children's learning of science concepts and theorising the development of concepts within science classroom discourse. The problem to which their meaning-making framework (MMF) was a response was captured by Anna Sfard's seminal paper, 'On two metaphors for learning and the dangers of choosing just one' (1998). Sfard is a prominent researcher in the field of mathematics education, who proposed two metaphors which explained two different perspectives on learning: the acquisition metaphor and the participation metaphor. The acquisition metaphor of learning refers to a process of acquiring knowledge or skills. From this perspective, learning is viewed through the lens of more traditional instructional models of teaching. Learning is seen as acquiring facts, and teaching is the transmission of these facts. It is a one-way transfer of information of knowledge. In this view, the learner is viewed as a passive recipient absorbing information which is stored in the learner's mind. Sfard contrasts this with the participation metaphor, which emphasised the active role of learners in the learning process. In contrast to simple acquisition, the learner is viewed as actively participating in constructing knowledge through interactions with others in discussion and their environment through practical activity. The participation metaphor views learning as situated within social interactions and practical activities. According to this view, meaning develops through collaborating with others and negotiating their understanding through discussions. While Sfard argues for the strengths and limitations of both metaphors, she suggests that teachers adopt a balanced approach to teaching and learning, warning of the danger of choosing one approach at the expense of the other.

Scott, Asoko and Leach (2007) presented a literature review of conceptual learning in science classrooms entitled 'Student Conceptions and Conceptual Learning in Science'. Sfard's two-fold metaphor of learning served as the foundation for organising their review of theoretical and empirical research on teaching and learning in science classrooms. According to Scott and colleagues the *acquisition* metaphor of learning views concepts in terms of individual possession and development of meaning as located within the learner. From this perspective, concepts are considered mental models or some form of local relatively fixed mental entity, 'it is *concepts* that are learned and then stored in the learner's head' (Scott et al., 2007, p. 35). The second metaphor relates to *participation*, where concepts are viewed as non-local and dynamic, where the development of their meaning is embedded within social interactions distributed across a community, for example the science classroom. Their review spanning the last thirty years, highlights a shift within science education from focusing on the individual learner to approaches that place increasing emphasis on the 'various *social* aspects of the learning process and of knowledge itself' (Scott et al., 2007, p. 35). Earlier, I referred to this shift as a 'discursive turn in psychology' (see Chapter Three, Bruner, 1990; Scott et al., 2007). The meaning-making framework offered a much-needed pathway to relieving the dichotomy reflected in Sfard's two metaphors and Scott and colleagues' literature review. Mortimer and Scott's research into meaning-making demonstrated how certain tensions remained within constructivist perspectives[89]. Scott's work exposed

[89] Scott and colleagues situate the sociocultural view of science learning within the acquisition metaphor of learning, they consider such a post-Vygotskian sociocultural approach as a form of social constructivism (2007). They claim that 'those contemporary approaches to conceptualizing science learning, which draw on

a tension between social interactions and personal meaning-making in science classroom talk (Scott, 1996, 1998). Mortimer on the other hand highlights a tension between shared and individual understandings in science conceptions (Mortimer, 1998, Mortimer and Machado, 2000). Simply put, they developed an approach to redress the problematic *relation* between learner thoughts (acquisition) and classroom talk (participation)[90]. They achieved this integration by operationalising Wertsch's post-Vygotskian sociocultural theory of development of mind and meaning (See Chapter Three).

Mortimer and Scott's meaning-making framework (MMF) made visible the role teachers play in developing learning and orchestrating classroom talk. In developing their *dialogic view* of learning and meaning-making (see Chapters Three to Four), they draw influences from both acquisition and participation metaphors of learning. They conceptualised science learning as an induction into a social-cultural practice into the *social language* of the school science community (Mortimer and Scott, 2003). This idea of science as a social language involved the science teacher in inducting learners into thinking and communicating in ways appropriate to the community. Despite their contribution and developments in science education

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Vygotskian sociocultural theory, are often referred to as social constructivist perspectives.' (2007, p. 41). Mortimer and Scott situate their analytic framework within a 'post-constructivist' paradigm. They draw an equivalence between these terms, they view them as mutually interchangeable. Mortimer and Scott's stake in the post-constructivist paradigm can be understood as moving from cognitive approaches to learning 'to those that take the social context as an integral part of the learning process. In short, we move from cognitive to sociocultural and social constructivist approaches.' (2007, p. 40). According to Mortimer and Scott , the meaning-making framework exemplifies how thinking about teaching and learning can acknowledge differences and distinctions while avoiding the pitfalls of making sharp or exclusive distinctions between epistemological perspectives.

[90] Their initial approach to conceptualising learning took inspiration from Vygotsky, which considers learning as *acquisition.* It was in developing their account drawing on Bakhtin which led them to account for more pragmatic features of learning, which they associated with the participation metaphor. The meaning-making framework, from their perspective was consider as approach that managed to successfully account for and integrate both metaphors of learning.

research (and fruitful research by Scott (1998) that addresses teacher talk and Mercer and Hodgkinson (2008) who focused on classroom talk) there remains limited research[91] on designing science instruction informed by social constructivist perspectives (Scott et al., 2007). Scott and his colleagues argue that pedagogic research has given less consideration to the step attending to individual learners' in meaning-making, both in theoretical and empirical studies. However, they believe that socio-constructivist approaches, unlike participatory approaches, provide teachers with valuable insights into their practice and 'offer a more plausible and helpful way of framing possible instructional approaches' (Scott et al., 2007, p. 48). In essence, what Mortimer and Scott achieve in conceptualising learning and developing their MMF, is a tool that represents classroom talk and teaching practice. Their framework renders classroom talk visible for professional discussion and informing teachers in planning and reflecting on science teaching and learning. They acknowledge a tension between the two metaphors of learning, which manifest in research and theorising meaning-making in the classroom. It manifests as sense-making of the individual in personal meaning-making (initial step) contraposed to meaning-making within social interactions (dialogic step). By adopting a post-constructivist paradigm, they consider themselves as transcending the limitations of cognitive constructions and personal meaning-making. Instead, they reframe these processes as socially constructed through the two-step process of *dialogic* meaning-making. However, despite Scott and Mortimer's important attempt to provide a robust framework for helping teachers understand how to use dialogue effectively in the classroom, this thesis argues that they do not succeed in what they intended.

[91] This is further illustrated in light of Derry who critiques contemporary trends that focus on cognitive load theory (2020), where again the approach detracts from the distinctive nature of human learning, interactions and activity.

Inferentialism, in contrast offers resources for helping teachers to appreciate the extent of what is involved in learner utterances in meaning-making interactions and classroom talk.

8.2 Conceptualisation of Science Learning Reorientated

The meaning-making framework (MMF) focuses on various forms of classroom talk and communicative approaches and offers a sociocultural and social constructivist perspective on the issue of teaching and learning science concepts. As such, it offers four key insights common to social constructivist perspectives on science learning, incorporated into their theorisation and analysis of classroom teaching and learning interactions. These include i) Learning *scientific knowledge* as involving a movement from the social to the personal plane (social context), ii) The process of *learning* is dependent on individual sense-making (internalisation), iii) Learning is mediated by *language* (externalisation), iv) Learning about *scientific concepts* involves introducing and being inducted into a new social language of science (communicative approach/ dialogic meaning-making). These key insights relate to various aspects of their theoretico-methodological (discourse analytic) framework (see discussions in Chapters Two, Three and Seven).

i. *Social Constructivism and Vygotsky:* 'Learning scientific knowledge involves a passage from social to personal planes' (Scott et al., 2007, p. 44). This draws on the idea that learners' concept development involves actively engaging in social interactions. Scientific knowledge is similarly conceived as developed in a social context of a scientific community.
ii. *Social Language and Bakhtin*: Science learning is viewed as developing a new social language within a new context/community. Learning involves a

process of conceptual addition as opposed to idea replacement found in early misconceptions approaches.

iii. *Scientific Content and Conceptual Profiles:* The multiplicity of meaning in ways of thinking and talking (social language) for an individual has been captured by the idea of *conceptual profiles.* Both everyday and scientific language and concepts constitute 'different zones of an individual person's conceptual profile' (Scott et al., 2007*,* p. 43).

iv. *Dialogic Teaching and Communicative Approaches*: Science learning is viewed as learning the social language of science and being introduced and inducted by some more knowledgeable others.

The implication of MMF's social constructivist view of teaching and learning is that *learning science* is an induction into a 'new social language, a new way of talking and thinking about the world.' (Scott et al., 2007, p. 44). The dialogic approach to teaching science MMF advocates involves *rehearsing* scientific ideas and language, clarifying the explanatory power of scientific ways of talking and thinking about natural phenomena, that is, the scientific point of view. Specific scientific ideas such as 'liquids can behave like solids' or 'air has weight' seem implausible or counter-intuitive because they stand in tension with everyday ways of talking and thinking. While the MMF and Mortimer and Scott's conceptualisation of science learning by integrating two metaphors have been fruitful in classroom research (Chapter Two), an issue highlighted by social constructivist studies more broadly is that the 'individual sense-making or internalization' aspect has received less attention 'both theoretically and empirically' (Scott, et al., 2007).

8.2.1 Inferentialism: An Epistemological Reorientation

In contrast, inferentialism poses an epistemological challenge to their socio-constructivist approach. Mortimer and Scott's conceptualization of science learning and their interpretation of 'meaning making' in dialogic terms (2003, pp. 11-12) is considered fundamentally problematic viewed through an inferential lens. Considered from within an inferentialist paradigm, Mortimer and Scott's '*dialogic meaning making'* remains confined to describing, categorising and naming representational features of inter-subjective communication or 'classroom talk', which does not itself provide an explanatory account. What such communicative activity consists in, or how and why we humans engage in it in the ways we do, are issues that still need to be explained. In privileging inference over representation, an inferentialist explanatory approach explains not by making relations visible or naming them but by describing what we humans do. By appealing to our rationality and judgments in the account of mind and meaning, inferentialism explains without appealing to reference or causal relations but from within a non-dual non-representational epistemological paradigm. In Brandom's phrase of term, even when linguistic practices are described, there is a need to provide an account of 'how the trick (of concept use) is done' but also 'what could in principle count as doing it- a normative rather than an empirical issue.' (2009, p. 222). In the present case, it applies to communication in developing a meaningful understanding of science concepts, i.e., learning.

Inferentialism 'reverses the order of semantic explanation' by taking the nature of inferential relations as fundamental and explanatory instead of needing explaining. Although such an approach may seem somewhat removed, innovative approaches can often seem strange. If we look back to when Lemke (1990) first introduced social semiotics and the idea of meaning-making into science educational research (see Chapter Three), he expressed the following sentiment: it ‘makes a lot of sense once you get used to it. But it has a way of talking about these subjects that can seem a little strange at first. Having read the rest of this book, however, you should find that much of what I will be saying in this last chapter will sound at least a little familiar.’ (pp. 185-86). In a similar vein, I want to take his comments in following Derry’s inferentialist restorative scholarship of Vygotsky as I outline the subsequent alternative theory of conceptual development it provides, not in terms of a psychological theory of mind but a non-psychological theory of our discursive rationality and human mindedness, as a normative as opposed to a solely cognitive or social affair.

An inferential approach is not only concerned with my linguistic performance or utterance, i.e., what is said. In attending to assertions, it is concerned with what is meant, i.e., the inferential articulation of my commitments and entitlements. The focus turns from linguistic utterances to reasons and reasoning articulated in thought and talk. In foregrounding our rationality in linguistic expression as knowing agents and concept-using creatures, inferentialism resonates at a deeper level that lies beneath surface-level linguistic performances. Speech acts are viewed as articulating my reasons or inferential role of a concept, expressing my reasoning. For example, coming to understand the concept ‘solid’ (inference-making) and applying the concept in making a claim (claim-making), I freely make judgments in articulating my beliefs (inferential commitments) in my saying (claims) and doings (actions, such as classification). According to inferentialism, correctly using a word or concept or making claims involves more than the utterance. It involves the normative notion of playing by the rules.

From an inferential perspective, I am not automatically correct in uttering 'sand is a solid'. Instead, the focus is on my commitments or presuppositions that lead me to express my judgment that 'sand is a solid'. In making this claim, I draw on related concepts, such as 'solids have shape', 'solids have a fixed volume' or 'solids have a measurable hardness'. The presuppositions I take in support of my claim determine the correctnesses of my use of the concept. For example, to be correct in using the concept 'solids', it is not enough to claim 'sand is a solid' or by placing the object (and material) 'sand' in the 'solids' category, although this may be a scientifically-oriented answer. Instead, the correctnesses of my claim is dependent on my commitments, which can be accessed and assessed by others through discursive interactions. Through giving and asking for reasons (for the claims we make and concepts we use), subject to norms and normative assessment by other legitimate players and their endorsements, I calibrate my concept use and develop my conceptual understanding of science concepts and discourse. This example illustrates the way inferentialism attends to the freedom learners exercise and the normative constraints of the knowledge domain, which expert teachers impose on our thought and talk in the science classroom. It offers a different interpretation of concept-meaning and its development. Learning and understanding science concepts lie in calibrating the inferential role concepts play in our thought and talk in playing the game with other legitimate players. With this distinction in view, I compare the inferentialist and socio-constructivist approach of MMF and illustrate how inferentialism reorientates key post-Vygotskian ideas relating to social interactions, language, concepts meaning and meaning and learning.

8.2.2 Epistemological Orientations: A Critical Comparison

I address each critical insight from Mortimer and Scott's social constructivist perspective on conceptual learning in science. I contrast each point with a response from an inferentialist viewpoint. I summarise these points in the table below (Table 24., pp. 279-280).

From Social Contexts to Normative Constraints

In following a 'social' constructivist approach, Mortimer and Scott emphasise the role of social context in providing an explanatory account of learning or individual construction. Conversely, in an inferentialist epistemology, the social and personal are viewed as always already an inseparable whole, subsequently requiring a vocabulary that views them as already part of a single process rather than as two aspects that need integration. In leading an explanation starting from our autonomous capacity in reasoning, social contexts and discursive practices are explained in terms of our reasoning articulated in social or discursive practice described in terms of the *game of giving and asking for reasons*. Our rationality is not to be developed after having *acquired* concepts or explained by our *participation*. Our rationality and developing our reasoning capacity lies in *mastering* concept application in norm-governed practices involving rational judgment and responsibility.

Inferentialism reorients the notion of this social context of intersubjective interactions as some third-person free-floating concept in which we participate. Such social contexts are norms/rules we institute through our social, rational, discursive, concept-using practices that bind us in playing the *game of giving and asking for reasons*. These norm-governed practices require a normative description, vocabulary and normative pragmatics. Socio-constructivist frameworks locate meaning in linguistic performance in context-dependent ways within social interactions (i.e., social languages, see §3.2 and §4.4). On the other hand, inferentialism focuses on *relational linguistics,* which focuses on the judgments we make in relating one sentence to others (reason and inferences). These rational judgments are expressed in our thought and talk and constitute our inferential rationality. Concept meaning is, therefore, not merely an issue of linguistics determined by social context (pragmatics). It is fundamentally a matter of inferential semantic relations articulated in using concepts in norm-governed discursive practices (normative pragmatics). From an inferential perspective, discursive practices are a game we humans play that involves rules (logical space of reasons) constraining our believings, sayings and doings. These all constitute moves players make in playing the game. An inferentialist perspective views social contexts as normative constraints on rational concept-using creatures that play games within given rules. A knowledge domain not only provides a social context but also sets the normative constraints or norms governing inferences, reasoning and discourse. The critical insight here lies in recognising how *social context* is devoid of normative awareness or inferential orientation to the space of reasons exercised by players in articulating reasons in discursive practice.

From Internalisation to Mastering the Inferential Role of Concepts

Socio-constructivism takes learning as the learner internalising social language via using or rehearsing language and ideas. While inferentialism does follow a use-theory of meaning (Brandom, 2011; Peregrin, 2014) or broadly pragmatics, it introduces a normative twist. Inferentialism reorients an account of this internalisation by viewing language as a *game of giving and asking for reasons.* It shifts the focus from language use towards our rationality and judgments in making inferences and normative moves in discursive practices. Inferentialism does not limit internalisation to using language as a tool or mediational means. This approach to language as a mediational means sets up a divide between the user and the usage, which then requires integration (See Chapter Four, §4.1 and §4.2). This divide manifests as the tension between acquisition and participation metaphors. Inferentialism moves beyond referring to sense-making or *internalisation* as located in the individual minds, involving relating words or concepts to their use in *social language*. Inferentialism does not interpret internalisation as a psychological affair mediated by language use in social contexts. An inferentialist or non-representational epistemology considers the process of '*internalisation*' as a non-psychological affair (Derry, 2020). Hence, it utilises normative as opposed to relational or representational vocabulary in explaining the development of concept meaning. *Inferentialist semantics*, thus, is able to attend to our rationality and judgments by reinterpreting *internalisation* in terms of making commitments and inferences in reasoning articulated in our social and discursive practices. These commitments, entitlement and incompatibility relations as constitutive of coming to grasp the inferential role of concepts is a normative affair. Coming to understand concepts is inseparably tied up with our inferential articulation, that is our thought and talk. The internalisation of concepts is tied to articulation in discursive practice as a normative practice and thus inseparably connected to the process of externalisation.

From Externalisation/Participation to Mastering Inferential Articulation of Concepts

MMF takes language and social interactions (classroom talk) as a means for the learner to internalise concepts. Various semiotic resources in the classroom mediate learning, this could be diagrams or models, the most crucial being language. Mortimer and Scott view thinking and talking as an interrelated process through which meaning develops (i.e., learning). Their post-Vygotskian theorisation locates the development of meaning in language (linguistics), which is mediated by use (pragmatics) conceived as a semiotic resource, a means by which meaning develops. The individual learner is captured by acquiring concepts in context-specific ways accounted for by participating in social language dependent on the demands of the social context. In this manner, everyday and scientific language and knowledge constitute 'different zones of an individual person's conceptual profile' (Mortimer and Scott, 2003, p. 125), which determines their use of concepts in classroom talk. They understand *externalisation* as the development of concepts through participation and linguistic performance within a social language community (science classroom discourse).

Inferentialism views language as a rational *game of giving and asking for reasons* involving autonomous concept-using players. It does not limit e*xternalisation* to participation or performance but normatively reorients the process as challenging and justifying the commitments, inferences or claims made in discursive practices. From an inferentialist perspective, e*xternalisation* is interpreted as *mastering* the inferential role of concepts, *responsive* to the norms of discourse (claim-making) in ways appropriate to the rules of the game (normative space of reasons). This discursive practice consists of normative assessments, as challenges, endorsements and calibration of our inferential commitments, and our reasoning as articulated in our discursive or deontic practices. Brandom's deontic scorekeeping model accounts for our intersubjective communication in normative pragmatic terms. Discursive practices, as socio-normative practices, are not psychological but non-psychological affairs.

8.3 Dialogic Meaning-Making to Deontic Scorekeeping: An Overview

Mortimer and Scott view learning and teaching as mediated by a communicative approach to classroom discourses. In their socio-constructivist view of learning science, learners rehearse the ideas of school science and the social language of science. From the sociocultural side, the teacher inducts learners into the social language and practices of the (school) science community. They explain the development of concept-meaning through classroom communication which serves as a *mediational means* that relate individual thought to social language. From an inferentialist view, the tensions between the different metaphors of learning arise from attempting to conceptualise and explain teaching and learning by appealing to some means or relations that integrate these opposing dichotomous aspects such as relating individual to social. Inferentialism interprets this situation differently (see also Chapter 4, §4.1on Pittsburgh School of Philosophy).

Through an inferentialist lens, there are no tensions to be resolved. A false dichotomy derives from the relation between individual learning (acquisition) and social use of language (participation) or between semantics and pragmatics. On an inferentialist account, language is viewed as a game with rules, as a norm-governed affair, involving players, as rational, autonomous concept-using creatures, in playing the giving and asking for reasons. In leading with inferential relations in an explanatory account of meaning and communication, as opposed to representational ones, rationality, semantics, and pragmatics sit together in a holistic, relational, functional, and normative framework. Our inferential reasoning (inferential semantics) as first-personal relations, as reasons articulated in norm-governed practices, draws a distinctive normative and inferential vocabulary that dissolves the very need to explain these relations. Instead, our reasoning in our normative practices explains what we humans do: giving and asking for reasons is a distinctive human and normative practice. Any induction into linguistic practices is, on an inferentialist interpretation, reoriented in terms of initiation into norm-governed (deontic) practices, that is, giving and asking for reasons as a player, a legitimate participant, in playing the game, in the sense of being accountable and responsible in the correct application of concepts. In mastering concepts, a player becomes responsive to norms governing discourse and gets better at making moves and playing the game. However, developing an awareness of appropriate inferential reasoning, mastering the permissible and impermissible moves in playing the game (inferential articulation of a concept) is not a one-sided affair. This was illustrated in classifying sand (see Chapter Five).

Playing the game involves not only making appropriate moves in accordance with the rules. It also involves tracking and tracing other players' moves and scores. Learning science is mastering the inferential moves in playing the game. The player becomes not only responsive to norms governing the game but also responsive to other players' moves and claims. I refer to scorekeeping practice as this ability to respond to other players' moves in relation to one's own and according to the rules of the games. Brandom views our communication practice as a deontic scorekeeping practice. Scorekeeping highlights a critical difference between Mortimer and Scott's and Brandom's approach to communication. Mortimer and Scott's communicative approach views classroom thought and talk as displaying certain forms and patterns to be captured, represented and rendered visible. In contrast, inferentialism views discursive practices as socially perspectival, that is always viewed from some player's perspective and presuppositions. Thus, the critical issue is the role concepts play in each player’s inferential network or semantic relations, constantly updated in challenging, responding and calibrating these relations according to the normative space of reasons. This process is made explicit by Brandom’s normative pragmatic account of scorekeeping (see Chapter Six, §6.1 for details). The induction into a social language in inferentialist terms is an initiation into a norm-governed game, a logical space of reasons and mastering moves in playing the game well.

Conceptualising Science Learning: Contrasting Epistemological Paradigms

Representationalist Paradigm: Post-Vygotskian Socioconstructivism	Inferentialist Paradigm: Restorative Vygotsky and Inferentialism
i. Learning and developing scientific knowledge involves passage from social to personal planes. (Social Contexts)	Science learning is coming to grasp the rules of the game in making inferences, claims and playing the game – mastering the inferential role of concept application. Inferentialism extends beyond social contexts and discursive interactions to acknowledge a knowledge domain as the norms governing discursive practice - a normative affair. The focus turns away from the social context of language-use as facilitating learning of scientific knowledge, towards normative constraint on reasoning.
ii. The process of learning is consequent upon individual sense-making by the learner. (internalization)	Learning is viewed as a player mastering the role of a concept in inference-making, in thought and talk of the classroom. Inferentialism moves beyond referring to sense-making or internalization as some inner process, to offer an account of this process consisting of inferential activity at both the cognitive level and discursive level by reconceptualising learning by employing normative vocabulary. The process of calibrating commitments, entitlement and incompatibility relations through dialogue is not only two-way but an ongoing dynamic and responsive process by the players involved.
iii. Learning is mediated by various semiotic resources, the most important of which is language (externalisation)	Learning involves a player mastering the inferential articulation of a concept in claim-making or discursive practice. Inferentialism moves beyond referring to externalization and extends the notion of language-use to view dialogue as rational *game of giving and asking for reasons*, that is a process of justifying and challenging the commitments one makes or claims.
iv. Learning science involves being inducted into the social language of the (school) science and scientific community, which must be introduced	Inferentialism acknowledges this induction but understands it to be not only into a community practice but privileges the induction into a normative practice of giving and asking for

to the learner by a teacher or some other knowledgeable figure. (‘dialogic meaning making’)	reasons. Players in participating in *deontic* scorekeeping practices develop *responsiveness to reasons* in navigating the *inferential space of reasons* and mastering inferential moves.

Table 24. Conceptualising science learning from two epistemological perspectives

In moving on to the final part of this thesis and bringing this part to a close, I recall a crucial question Mortimer and Scott narrate from an education conference. A teacher responding to Vygotskian theory exclaims, ‘what does Vygotsky have to do with teaching?’. Mortimer and Scott respond to that question by making the ‘invisible nature of classroom talk’ visible. I seek to provide an inferentially reoriented response. I claim that not only does the nature of concepts and character of classroom talk need to be made visible to teachers, but more crucially, such representational approaches need to be made *explicit* for teachers. This explication involves engaging in challenging and endorsing claims concerning their own commitments, that is, in playing the game *of giving and asking for reasons*.

Socio-constructivists consider that ‘given the complexity of what goes on in classrooms as students learn science, it is unrealistic to expect that one “grand” theory might capture all of the activity.’ (2007, p. 48). Subsequently, they attempt to develop ‘complementary perspectives on learning.’ (ibid.). However, I consider that within a holistic epistemological reorientation, such theorisation would not seem so ‘“grand”’ (ibid.). Rather than ‘complementary’, perhaps a more fruitful approach would be ‘perspectival’. The last three chapters developed and constitute an inferentialist reorientation of meaning-making. With this theoretical and analytical re-conceptualisation of knowledge, meaning and learning now in view, in the next two chapters I consider inferentialism in relation to the practical classroom context of teaching and learning in primary classrooms.

Part III: Practical Implications

9 Inferentialism and Primary Science: The Case of Planet Earth

In previous chapters thus far, I have focused on theoretical and analytical aspects of Mortimer and Scott's framework, addressing the central concept of concern, meaning-making and classroom talk. In the present chapter, I turn my attention to the practical context of primary classrooms, where I draw on my fieldwork working collaboratively with a Year 5 primary science lead in thinking and talking through science topics and concepts, planning science lessons discursively (Appendix 5-7). Below, I present three vignettes from our work together to articulate the inferential lessons illustrated in previous chapters. The vignettes concern the Science topic Earth and Space. This initial episode is a collaborative exploration of the primary science curricular topic and concepts in initiating a teaching sequence. The second vignette concerns thinking about the Earth as flat or round. The third and final vignette draws on the closing episode in discussing Earth's seasons. As I explore an inferentialist orientation to thought and talk in primary science classrooms, I address certain implications of inferentialism for classroom talk in teaching and learning primary science drawing on the vignettes.

9.1 Planning Earth and Space: Planets to Planethood

As part of my fieldwork, I worked closely with Ms Kapoor, a Year 5 teacher and the science lead at a London-based primary school. I joined her in planning and preparing her teaching sequence on the topic of Earth and Space. Our initial discussions involved the science topic Earth and Space and related concepts. As we discussed her initial lesson plan and teaching sequence, Ms Kapoor presented a worksheet that would require pupils to label the planets in our solar system (for example, see Fig. 20. below). According to the Department for Education (DfE), the National Curriculum for Primary Science in England and Wales (2013) requires the topic Earth and Space to be taught in Year 5 (pupils aged between nine and ten). The programme of study (DfE, 2013) for Year 5 states that children should be taught about the 'movement' of Earth and Moon and to 'describe the Earth, Moon and Sun as approximately spherical bodies' (ibid.). Using ideas related to the concepts of 'movement' and shape (i.e., 'spherical bodies'), teachers are required to explain the rotation of the Earth and the phenomena of day and night along with the 'apparent movement of the Sun across the sky' (ibid.). Government guidelines also suggest introducing models of the Earth and Sun to explain such phenomena. In addition, these guidelines suggest pupils learn certain scientific facts about our solar system, such as 'the Sun is a star' orbited by 'eight planets' and understand that moons are also celestial bodies that orbit a planet, as is the case with our own Moon.

Worksheet: Label the Solar System[92]

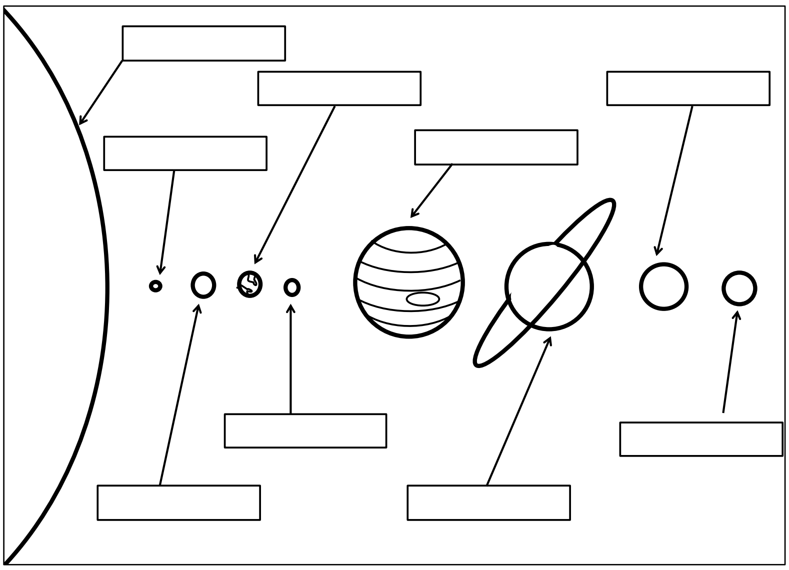

Fig. 20. Label the Solar System

[92] This resource was sourced from the TES website and a worksheet named 'Label the solar system'.

As we discussed follow-up activities, I queried whether her pupils in undertaking the activity would understand what planets are. She responded in the affirmative. However, the query initiated a discussion on our own ideas about planets. In thinking about what planets are, Ms Kapoor suggested planets were things that ‘*go around the sun*’. In fleshing out our ideas, we encountered counter-examples, such as the Moon, asteroids and Pluto, which also ‘go around’ the sun but are *not* ‘planets’. In developing and justifying her initial assertion, she added, ‘*planets also have moons*’. The challenge here was that Mercury and Venus do not have moons. As the discussion developed, it inspired another query, ‘what about the Sun? Is the Sun a planet?’. In thinking about this for a moment, Ms Kapoor replied, ‘*No! The Sun’s not a planet…is it?*’. Through discussion, what started out as a simple and self-explanatory concept, namely ‘planet’, quickly became an obscure and problematic idea. What had become increasingly evident, which we came to realise, was that much more was at stake than we had initially assumed. It was clear that our initial everyday concept of ‘planets’, simply tied to the idea that it is ‘anything that goes around the Sun’, would fail to hold up in the face of closer scrutiny, especially in classroom talk with children. With this problem looming large, it was together that we sought a more coherent, robust and systematic account of what is, in fact, entailed by the scientific term ‘planet’. The labelling worksheet was set aside as we sought to understand this concept and subsequently related ideas better. The process not only informed the planning of the first lesson but served to reorientate our thinking and provide a systematic understanding of the entire teaching sequence.

9.1.1 Inferential Nature of the Concept 'Planet': The Case of Pluto

The seemingly simple question 'what is a planet?' does not have a simple answer. In 2006, the International Astronomical Union (IAU) revised their definition of 'planet', resulting in Pluto's demotion from a planet to a 'dwarf planet' (NASA, 2022). This decision and the subsequent definition continue to be a topic of vigorous debate among scientists today (NASA, 2022; Boyle, 2009). According to IAU, three key components currently serve to identify and define a celestial body as a 'planet', which are (a) in orbit around the Sun, (b) approximately spherical due to its mass and gravity and (c) a body that has cleared its orbit of other celestial bodies (NASA, 2022). This landmark revision of our scientific understanding and definition of the concept of 'planet' introduced compelling reasons, providing robust and more persuasive thinking in our discussion and lesson planning. We became aware of how understanding and using the concept of 'planet' entailed a host of relations to other related and consequential concepts, such as the 'shape' of planets and their 'movement' in relation to other celestial bodies in our solar system, including the Sun. The meaning of this single concept was part of an (inferential) network of concepts and claims and constituted part of the systematic or norm-governed discourse.

Pluto was deemed a planet by a community of scientists whose definition of a 'planet' was primarily informed by astronomers (Boyle, 2009). In the wake of an increasingly populated outer solar system, the orbit of celestial and planetary bodies and the definition of 'planet' came under closer scrutiny. The idea of a 'planet' as previously determined by size and movement in relation to the Sun was revised to include other salient features, such as movement relative to other celestial and planetary bodies. The trajectory of Pluto's orbit fell into the slipstream with Neptune.

It was this feature that instigated the re-assessment and revision in the meaning of 'planet', comprised of planetary scientists as opposed to astronomers alone. The subsequent debates and discussions within the IAU led to the reclassification and demotion of Pluto from a 'planet' to a 'dwarf planet' (Boyle, 2009; NASA, 2020). However, this was not an open and shut case. The verdict remains open and continues to be a topic of much-heated debate among scientists. The pages of popular scientific magazines and academic journals remain active. The scientific community remain divided, from those that recoil from an overpopulated solar system by permitting Pluto as a planet to those open to considering our own Moon as a planet locked in a binary orbit with Earth (Battersby, 2015). The whole concept of planethood remains on unsettled grounds, seemingly up for grabs.

From an inferentialist perspective, science concepts, such as 'planet', are rules that govern our thought and talk, that determine the correct usage of a concept. The meaning of scientific concepts is understood as constituted by the inferential role they play in our reasoning, expressed as logical compatibility and incompatibility relations in scientific discourse and the claims or propositions we make and exchange. These (inferential) relations constitute a systematic network, a logical space that determines legitimate and illegitimate moves. The systematicity of these moves constitutes the norms or rules governing science discourse and assertions articulated by concept-users in social practice and discursive communities, such as the scientific community (see Chapters Five to Seven). In an account of concept meaning, such as 'planet', inferentialism gives pride of place to the systematic nature of the relations between claims and propositions. Discursive practices, in inferentialist terms, are viewed as a *game of giving and asking of reasons*. These norms are rules of the game, that is, inferential rules that govern and constrain how concepts *ought* to be applied in thought and talk within a given community, such as science or IAU. In the case of Pluto, according to an inferentialist interpretation, it is not enough to recognise the shift or change in the use of language and terms in scientific discourse. It is not what is central to explaining concept-meaning and use. This requires acknowledging the changing role of the concept according to the norms or rules governing the use of the word 'planet' in playing the game within scientific discourse. The language, reasons and norms in using the concept 'planet' are constantly in formation, dynamic, organic, and evolving. In the present case, the concept of a planet not only considers the size and movement relative to the Sun but also to other bodies and the relative stability of its own orbit. The rules determine whether a celestial body is ruled in or ruled out as a planet. This fundamental idea of concept meaning rooted in rational judgments of concept users and constrained by the rules of the game accounts for the normative character of concept-use. The rational judgments as reasons justify and defend the demotion of Pluto, which underwrites the meaning of the concept 'planet', that is, the inferential role it plays in scientific discourse.

As scientific observations have become more detailed and our ideas and understanding of the entire universe have expanded, the solar system and planets can no longer be viewed through the narrow lens confined to, defined, named and labelled in relation to our own solar system. With the discovery of exo-planets[93], an increasingly populated outer solar system and the addition of the James Webb Space Telescope (JWST), cosmology is an exciting field of study on ever-shifting (possibly paradigm-shifting[94]) grounds. From this contemporary view of Earth and

[93] An 'Exoplanet' is defined as a 'planet that orbits a sun other than our own' (Stevenson, 2010b).
[94] At the time of thesis submission this claim was speculative. Recent observations and data received from JWST are now challenging current cosmological theories and may potentially require a shift in cosmological

Space, there is certainly much more involved in the concept of the planet than initially assumed or reduced to a change in definition. It is part of an ongoing 'social game of giving and asking for reasons: commitments, endorsements, and entitlements are *attributed*, *acknowledged*, and *undertaken*.' (Bransen, 2002, p. 374).

9.2 Planning and Teaching within a Space of Reasons

9.2.1 Earth, Flat or Round? Planning an Opening Lesson

As we continued our discussion on planets, we started to think and discuss the 'shape' of Earth. Ms Kapoor was confident the Earth was 'round' - until faced with the challenge of justifying her claim and thinking. A question that emerged during our discussion was, 'if the Earth is round, then why does it seem flat?'. This challenged our own beliefs (inferential commitments), animating deeper 'reason-mongering'[95] discussions. Moving on from the initial question, 'what is a planet?', our inquiry led to a series of related questions, which required a more convincing and coherent set of reasons. We looked into *why* Pluto *is not* a planet but also considered *why* Neptune *is* a planet. Subsequently, we considered counterfactual questions (and reasons) such as 'what would make Earth not a planet?' or 'what would make our Moon a planet? Our discussions led to a series of revisions in our own understanding and presuppositions about the 'shape' of Earth (commitments and entitlements). Having to justify for ourselves why the Earth is a planet and not the Moon made us appreciate how our everyday notions, in contrast to scientific understandings, play different roles in thinking, explaining and justifying certain phenomena. For example, by understanding planets as 'spherical bodies', rather than taken simply as self-

perspective and the present paradigm. However,, this is fast becoming an area of scientific debate and visible in popular science (O'Callaghan, 2022; Boyle, 2023; Koberlein, 2023).

[95] This is a play on Brandom's term that view us and our social discursive practices not only as a game of giving and asking for reasons but as part of our behaviour as concept-mongering practices. (2001, p. 190).

evident facts, we came to recognise how the notion of *curvature* accounted not only for how the Earth is (approximately) spherical in shape but its perceived flatness as relative to the point of observation. It was difficult for us to explain our knowledge that the Earth was 'round' and our everyday experience of the Earth being flat. Ms Kapoor knew we could resort to photographs from space, like the famous Earthrise photo from the Apollo 11 mission to the Moon. Yet, as I discovered, the internet is plastered with claims of hoaxed moon landings and photographs of the Earth. For example, the Flat Earth community has become a growing social movement, which inspired the Netflix documentary with the apt title 'Behind the Curve'.[96] Given our discussions and such debates, these issues filtered into our thinking about how we could respond in more robust and persuasive ways to such challenges.

In the present age of emerging commercial space flights, people may well be able to see the Earth from space for themselves. However, the curvature of our planet is not only visible from space. In exploring Earth from space, we discovered the record-breaking free-fall jump or space-diving, by Felix Baumgartner who jumped from 128,000ft (39km). Brian Binnie recorded the highest altitude for human flight in a fixed-wing aircraft at 367,490 ft (112,010m). They both observed the curvature of Earth. Our search led us to discover that you can observe the Earth's curvature from 30,000ft and above. We came to understand the curvature of Earth in support of a round Earth is not a modern discovery, but an argument that has been made earlier by Greeks, Egyptians, and Indian scholars **(**Skamp and Preston, 2015; Australian Academy of Science, 2014a; Twinkle, 2017). In preparing for our discussions, I selected resources that address this point, along with references to historical

[96] This relates to interesting and relevant discussion regarding evidence, inference and realism. However, due to limitation of space in this chapter, I limit my focus to providing a case study in illustrating the inferential role of concepts and normative space in teaching and planning science lessons.

accounts of observations made by Eratosthenes[97] and Aristotle[98] presented within primary science resources. These were incorporated into an opening lesson that sought to problematise the shape of the Earth, aimed at leading towards a meaningful understanding of the shape of the Earth as spherical or 'ball-shaped' (Skamp and Preston, 2015), as opposed to authoritative claim or scientific fact. Thus, this aspect of responding to 'what is a planet?' served as a starting point for the entire teaching sequence.

In this manner, we approached concepts with a newfound appreciation for debate, revision and openness to challenge, not only *of* science itself but as related to our own thinking and reasoning *about* science. Discussion and exploration of Earth and Space concepts in more inquisitive, thoughtful and critical ways offered Ms Kapoor and me an opportunity to participate in the *game of giving and asking for reasons* for ourselves. In problematising our everyday experience of the Earth being flat, it served to obscure our taken-for-granted notion of the Earth as a sphere. This offered an opportunity to reflect and revise our presuppositions and own thinking (commitments and entitlements). Acknowledging for herself her own incompatible and compatible commitments/beliefs served as an entry point into the science topic as a holistic conceptual space that re-oriented the approach to planning the lessons and sequence. Thinking through the topic, using and adjusting her presuppositions, and reorienting her own conceptions, offered Ms Kapoor first-hand experience and first-personal perspective on the ways she could engage her pupils in classroom discussions[99]. In navigating a web of reasons, she developed an orientation to a

[97] Eratosthenes story involves inferring the curvature of the Earth from making calculation of the shadow cast at Alexandria and Cairo.
[98] Aristotle's story involves an account of his observation of a ship travelling into the distance, which rather than getting smaller, appeared to sink.
[99] Our co-planning session not only fuelled her curiosity but also her confidence in both engaging with her pupils in classroom talk but also moving between obscuring and clarifying their ideas in persuasive ways about

norm-governed space of counterfactual possibilities and implications for herself. Our initial discussion thus served to induct Ms Kapoor into an entire network of ideas that could synthesise concepts into an integrated space of consequences. The systematic relations between an array of concepts served to plan the whole sequence while bringing into focus the significant links (i.e., consequential relations) between each lesson as a network rather than limited to a linear sequence. In thinking and talking about the topic, the teacher developed a particular sensitivity and responsiveness to the various ways a term or claim could or would be compatible or incompatible with other claims or concepts. She came to grasp the appropriate and inappropriate uses of science concepts for herself. Understanding these concepts' role in thought and talk would allow her to better engage and respond not only to what her pupils say (asking for reasons) but to what they may mean (tracking and assessing moves and scores). In this manner, the teacher could avoid slipping into a representational mode in teaching that simply sought the ‘right answers’ in labelling, naming, classifying or one-word answers such as calling out the name of a planet or knowing Pluto is not a planet. Opening a space of counterfactual possibilities also allows the teacher to avoid resorting to telling them what they need to know, as reflected in her initial approach to using the diagrammatic worksheet.

Viewed through an inferentialist lens, planning and teaching science involves more than science concepts, vocabulary or the scientific narrative. It involves the teacher’s recognition and sensitivity to the inferential network of relations that hold between concepts and claims in more precise and coherent ways that constitute

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the shape of the Earth. This was made evident in incident Ms Kapoor recounted in our post lesson review. She reported on a meeting with the school head teacher. She described how the headteacher was astonished by her understanding displayed in her presenting and explaining her lesson plan (see Epilogue).

scientific discourse. The teacher's sensitivity to the richness of a concept's meaning allows her to recognise that knowing scientific vocabulary and using such terms in the correct context does not by itself make a concept such as 'planet' meaningful for children. Approaching teaching with this awareness allows her to appreciate that there is far more involved in teaching and learning than knowing the concepts or vocabulary. The present illustration suggests as the teacher progresses through the lesson sequence, the teacher ought to gain a better understanding about the content and relation between concepts across the entire topic as a unified whole. As the topic sequence develops, covering an increasingly extensive and more complex network of ideas, attending to and responding to pupils' claims and background beliefs becomes increasingly more challenging. In the remaining sections, I plan to focus on the challenges primary teachers face in teaching and talking with children for a meaningful understanding of science and scientific language.

9.2.2 Teaching Sequence as Navigating a Space of Consequences

Through a series of discussions examining our thinking and presuppositions, we came to recognise and appreciate just how difficult it is to develop a coherent and convincing account of the shape of our planet. Understanding the role shape plays in thinking about Earth and lesson planning developed our understanding of the planet concept. Our query of whether Earth is Flat, Round or Spherical problematised the shape of the Earth as some taken-for-granted, given fact, and served as an appropriate entry point into the topic. Furthermore, the issue was well established in primary science literature, which provided supporting resources to incorporate into our planning of classroom activities.

Earth, as a planet, is considered a massive, spherical object, displaying curvature, rotation, and numerous other features, such as an axis and poles. These ideas all serve as reasons for thinking and talking about a constellation of ideas related to celestial bodies, such as ‘movement’, ‘revolution’, ‘the Sun’, ‘the Moon’, ‘light and shadow’, ‘day and night’. However, the very same concepts that flesh out the concept of ‘Earth’ also serve to think about, explain and explicate concepts such as ‘night and day’, ‘phases of the moon’, ‘space’, ‘time’, ‘days’, ‘years’ and ‘changing seasons’ – these all apply to planets but also Pluto. These concepts as terms or claims are related to other concepts in coherent and systematic ways, providing an interrelated network, a logical space of reasons that constitute the domain knowledge or discourse. In an inferential mode, the teacher navigates this space as she inducts her pupils into these systematic relations that constitute the correct use of concepts in coming to think, talk and do activities in the science classroom and lessons within the scientific knowledge domain. In planning science lessons, the teacher not only needs to know science concepts as a body of scientific facts or as a list of vocabulary to be covered. She needs to have *mastery* of the logical relations or inferential role concepts play in thinking and talking with the scientific discourse. In other words, she needs an inferential orientation in navigating the scientific knowledge domain or playing the *game of giving and asking for reasons*. For any given concept, she understands what concepts or set of claims or propositions it follows from and what claims or propositions may legitimately follow from it – its inferential role in reasoning and discursive practices. Following Brandom, Derry refers to mastering concepts as a *practical know-how* in articulating reasons. The appropriate application of a concept constitutes the concept-meaning, which Brandom expresses as follows:

> Grasping the *concept* that is applied in such a making explicit is mastering its *inferential* use: knowing (in the practical sense of being able to distinguish, a

> kind of knowing *how*) what else one would be committing oneself to by applying the concept, what would entitle one to do so, and what would preclude such entitlement. (2001, p. 11)

Brandom's philosophy of language and his approach to semantics reveal the inferential nature of concepts and the norm-governed character of concept-use in thinking and talking about science. His meta-vocabulary in talking about our discursive practices makes these inferential dimensions explicit. Moreover, his inferentialism alerts teachers and researchers to a whole other dimension that makes our thoughts and talk meaningful, namely, rules and reasons. Concepts and conceptual contents (meaning) are not atomistic entities residing 'between the ears of the individual' (Brandom, 2011, p. 4), nor are singular terms that refer, name, label or classify – that is, serving as representations. They are instead considered part and parcel of an interrelated network of claims, a synthetic and organic whole as part of an ongoing social and discursive practice. An inferential approach recognises patterns in thought and talk that follows from being responsive to the systematic nature and logical relations that hold between propositions articulated in norm-governed use of concepts in discursive practice. Such inferential patterns are made explicit by specific reasons articulated by players in applying concepts. Any claim is a consequence that serves as a premise in justifying a claim and other claims it serves to justify. These form the logical or inferential patterns in a norm-governed game of giving and asking for reasons. In other words, the appropriate ways of thinking and talking in the science classroom.

Highlighting these moves in lesson planning and classroom interactions sits in contrast to representationalist approaches. It foregrounds inferential norms governing moves underpinning an inferential mode in teaching. To engage in quality dialogue with children, the teacher needs to have mastery of the inferential role of concepts in a norm-governed discourse. Such mastery grants the teacher the capacity to unpack concepts in relation to underlying commitments and extend them to other concepts and claims in line with norms governing discourse. Children, in making claims, articulate reasons. These claim-making moves in classroom discourse express their capacity for inference-making and responsiveness to reasons and norms of discourse. These rules constitute the knowledge domain. This logical space and normative constraints become the focus of teaching and learning as a matter of priority rather than the language, vocabulary, or its use. Of course, this would not be possible without language, but inferentialism interprets our linguistic practices as *giving and asking for reasons*. It is the logical relations articulated in the claims as opposed to the linguistic performance itself, which is privileged on an inferential approach to planning, teaching and classroom talk. These logical relations are multifarious and manifest in the classroom talk as an expression of teacher responsiveness to pupils' claims and judgments. For illustrative purposes, I have sought to provide a limited representation of the teaching sequence as the teacher's navigation through the space of reasons (see Fig. 21., p. 296). However, this is not a fixed schema but an illustration of one way in which our discussion manifested as the teacher's logical relations, her semantic responsibility and her freedom in navigating a space of reason in planning and responding to pupils and classroom talk.

Planet Earth Concept: Our Inferential Moves in a Normative Space

a. Earth, curvature, spherical, planet.

b. Movement and motion relative to Sun and Moon (i.e., visible celestial bodies)

c. Phases of the Moon: (relates to Orbit and Light and Shadow)

d. Sun, Planets and other bodies in our Solar System

e. Day and Night (related to Sphere, Rotation, Axis, Light and Dark)

f. Seasons of the Year

g. Forces and Gravity: Although these concepts underpin every related concept, they need not be made explicit in relation to the central focus of this topic or inferential space of reasons or the rules of this game. For example, in discussing a planet’s shape and size and orbit, the mass of the body and gravitational field are central but need not necessarily be foregrounded or made explicit in primary science discussions. However, they remain judgement calls for the teacher to make in preparing activities and engaging children in classroom discourse.

Illustrative Representation Teacher Navigation of Earth and Space

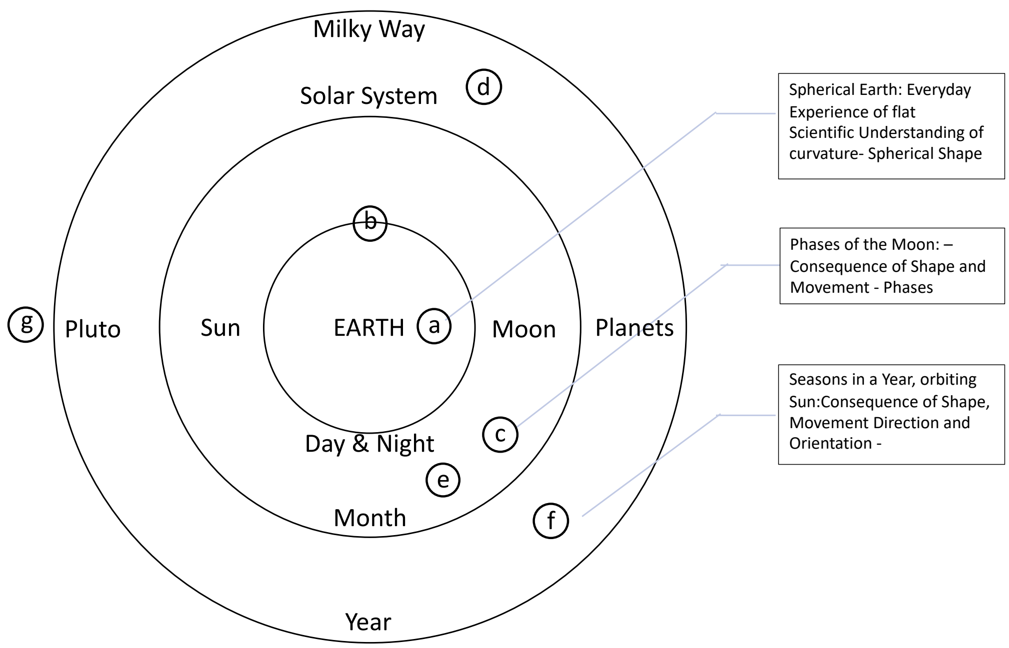

Fig. 21. Teacher's navigation of Earth and Space topic

The teacher has a responsibility for planning lessons and teaching sequences. This responsibility lies in being able to play the game well and being responsive to the rules of the games and the moves players make. The expert teacher has sufficient concept/practical mastery in navigating and orienting herself to a given sequence and various consequences, looking upstream and downstream. The teacher, in scientific discourse, must be able to recognise the (inferential) role science concepts play in thinking and talking in the science classroom (the game of giving and asking for reasons). Developing her pupils' conceptual understanding and responsiveness to the systematic relations requires an awareness of the norms that govern the correctnesses of concept application that constitutes conceptual content (i.e., concept meaning) in classroom discourse. This development involves inducting them not only into the language of science but, more importantly, into the *space of reasons* articulated in the systematicity of using concepts in domain-appropriate ways. In other words, the teacher develops an (inferential) awareness of their norm-governed inferential role in science classroom thought and talk.

9.3 Science Teaching as Normative Assessment within an Inferential System

9.3.1 Closing Episode: Earth's Seasons

In the last two lessons of the teaching sequence, Ms Kapoor had lessons on 'day and night' that led into the concluding lesson focusing on the 'seasons'. The last lesson addressed ideas relating to the Earth, its axis, rotation and tilt in relation to axis relative to the orbit around the Sun. Ms Kapoor felt she had developed a much better understanding of these concepts and the systematic relations between them developed through the preceding lessons. All the previous concepts fed into planning her last lesson on 'seasons'. In evaluating the last lesson, she claimed:

I think it went well. I thought the lesson was planned out so well that nothing can go wrong,…

Ms Kapoor felt she had a good grasp of the science content and vocabulary involved. During the course of the lesson, she describes how certain challenges arose:

…but the vocab (pauses) the words… I wanted them to use, it wasn't coming out like.. it just…it's like I literally had to put it in their mouths for them to say what they're supposed to be saying, which is the sad part. You really have to be literally have to be really explicit for them to get it. Like when I was demonstrating … I thought they'd get it, but they didn't.

During our planning we decided the concepts 'tilt', 'axis' and 'orbit' would play a key role in demonstrations and classroom dialogue. A scientific explanation of seasons utilises an understanding that the Earth has a 'tilt' as it rotates on its 'axis', which it retains as it 'orbits' the Sun. This tilt in Earth's axis results in variation in the angle of incidence of the sunlight depending on your location on Earth. For example, in the equatorial regions the incidence of sunlight is more direct (straight on/powerful) and, as you head to the poles becomes increasingly indirect (angular/diminished), which underpins an understanding of the seasons (see illustrations below Fig.22-24).

Fig. 22 Earth's seasons

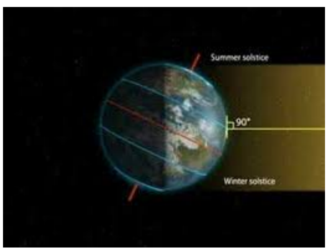

Fig. 23. Earth's axial tilt


Fig. 24. Earth's curvature

After the last lesson, we discussed this particular episode about explaining seasons and demonstrations. Ms Kapoor recognised and understood the central (inferential) role that the concept of Earth's 'axis,' 'tilt', and 'sunrays' all play in explaining the idea of seasons. As she mentions, she felt the lesson went well and had confidence in the lesson plan addressing the vocabulary, activities and assessment acknowledged by her claim 'planned out so well nothing could go wrong'. In the classroom, however, demonstrating and discussing the Earth's movement with her pupils, although the concepts' tilt' and 'season' were employed, it did not make explicit the role of the concept 'axis'. Consequently, the concept was not articulated in the classroom discourse either. The issue is not that the vocabulary 'axis' was not addressed. On the contrary, without this concept of 'axis', a series of inferences were not made explicit. The related ideas that follow from the concept 'axis' consequently were not made available to her pupils in classroom talk. Ms Kapoor described the classroom discussion thus, claiming the 'vocab, the words I wanted them to use were not coming out'. During our post-lesson discussion, it came to light that although the teacher had used the term 'tilt', the related concept 'axis' on which the concept 'tilt' rests was not brought in nor made explicit in the classroom thought and talk. In our discussion, she responds: '*did I not say it? In my head I'm saying it, but I'm not saying it!*'. Her surprise speaks to how easily we take for granted the nature of making explicit the words we use and the meaning we intend to convey.

Inferentialism addresses the nature of our rational judgments, responsiveness and responsibility in discursive practices and thus spotlights the role of articulating reasons and making them explicit in thought and talk. However, Ms Kapoor managed to skilfully continue the lesson, recognising her pupils had not fully grasped the concept of seasons. Since they were not relating claims and concepts to the concept ‘axis’, this led Ms Kapoor to repeat specific claims. She reiterated aspects of the demonstration in the hope that they may make the necessary inferences, amplifying their reasoning, that would result in saying the right things. As she notes, however, ‘the words were not coming out’ and she ‘had to put it in their mouths’. The issue of focusing on vocabulary, whether it be planning, resources or classroom talk, there is a risk of slippage into a representational mode. In this approach, the focus falls back on saying the right words or resorting to authoritatively telling pupils.

Even though Ms Kapoor grappled with explaining seasons, her grasp of the systematicity of concepts was visible in her lesson planning and discussion with pupils. Her lesson plans over the sequence displayed a cumulative growth of vocabulary that would relate to previous lessons in ways that would justify the present lesson. In addition, our ongoing discussions allowed us to check, assess and challenge the role of concepts in thinking and talking science, which informed a systematic continuous flow of reasons from one lesson to the next. I consider this preparation and familiarity with the content and continuity a significant factor in managing her teaching well. It permitted her to continue to teach confidently and engage her pupils in the discussion, where she felt comfortable enough to continue asking questions and giving specific justifications. In the remainder of the lesson, she discussed the rotation of the Earth. Relating this to the orbit around the Sun allowed her to discuss the concepts of time and seasons. At one point, a pupil thinking about the Earth’s position as related to time exclaimed in a revelatory manner, ‘so, it’s evening now!’. It seemed to indicate that the child began to relate these ideas to her everyday experience of time and the position of the Sun, as giving reasons concerning the thought and talk of the science class.

Teaching seasons or science topics can be ‘tricky’ (Rutledge, 2010), especially for non-specialist teachers with little or no background in science. In this manner, ‘background information’ or the teaching sequences commonly found in primary teacher resources do not themselves suffice to support the teacher faced with discussing scientific ideas in meaningful ways with children. In addressing the research on dialogic teaching in classrooms (Chapter Three), I discussed how researchers highlighted an emerging gap between dialogic theory and the practical reality teachers face in their classrooms. I suggest, following the inferentialist perspective, that the teacher needs more than knowing the science concepts she teaches (know-that) or an approach to learning those concepts (know-how, e.g., dialogic theory). In order to engage and develop children’s thinking and understanding, she needs to have grasped and mastered for herself, from a first-personal perspective, what science concepts *do* in thinking and talking about such topics (i.e., a *know-why* or inferential reasons). On an inferentialist account, meaningful understanding lies in applying concepts, taken as giving reasons to support specific claims while giving reasons to reject others. For example, the Earth’s movement supports specific claims about the ‘phases of the Moon’. However, it serves to reject other related claims, such as the ‘changing shape of the Moon’ or the ‘rising and setting of the Sun’ and apparent movement across the sky. In grasping the application of concepts, the teacher cannot only engage but also calibrate her pupils’ thought and talk in the classroom. The teacher not only needs to know what concepts or vocabulary to use but requires a certain mastery over the inferential network of concepts. In other words, having a particular (semantic) responsibility, she can give reasons in justifying knowledge claims she makes or employs in classroom thought and talk. The teacher requires this responsiveness to reasons if she is to help her pupils develop a meaningful understanding of science concepts and scientific discourse.

9.3.2 Systematicity of Classroom Science Talk: Learning to Play the Game, Well

This lesson illustrates how negating a conceptual node within the network of concepts, such as 'axis', has consequences for teacher assessment within classroom talk in all subsequent claims and assertions. The concept of 'axis' is related in multifarious ways to the talk of the Earth's position, movement and orientation in explaining seasons. This episode illustrates how teachers, when faced with difficulties, may easily slip back into a representational mode, focusing on right or wrong answers or inert factual claims. This slippage is a challenge that requires attention if we are to better support teachers in talking about science and using science concepts with children for a meaningful understanding of science.

The inferentially oriented teacher has an unspoken structure that allows her to make explicit her pupils' reasons through classroom talk. For example, a child may understand that a planet is round and orbits the sun but may consider the moon a planet while correctly referring to it as a moon. The teacher is receptive and responsive to reasons articulated by her pupils in what they say and do, allowing her to discern their inferential commitments. This responsiveness to reasons, in turn, enables the teacher to calibrate their inferential reasoning expressed in discursive practice. It involves an assessment of classroom talk. The teacher checks whether the children grasp the reasons that justify their presuppositions. The systematic network of reasons underpins the scientific language or, more precisely, the correctnesses of the scientific language- it is a *normative assessment* (Brandom, 2009, p. 35). The child's claim and entanglement are not clear cut, nor is it easily resolved or identified. This is precisely why one-word responses in classroom dialogue are so problematic for teachers faced with assessing learners' conceptual understanding (See Chapters Six and Seven for illustration).

Any teacher invested in their pupils' learning would, of course, ask for reasons. However, inferentialism alerts teachers to the inferential mode in which the teacher approaches classroom talk. Unpacking children's presuppositions (acknowledging and attributing commitments and entitlements), requires an inferential orientation to the knowledge domain. The inferentially-oriented teacher is responsive to the logical semantic relations that constitute the inferential structure and norms governing the science classroom discourse. Although a child may use the term in the right way or do the right thing, he may not be committed to the appropriate consequences. It may only become apparent in dialogue or classroom talk that follows, where they articulate their reasons for the inferences they make and the inferences they draw. The teacher engages in discussion not just to assess if they are using the words or vocabulary in the right way but to assess the correctnesses of their reasons. For the teacher, classroom talk is not just getting to grips with using the language in appropriate ways. The classroom talk becomes a form of assessment of whether they understand the logical use of concepts, which is an awareness and responsiveness to the reasons constituting their conceptual content.

9.4 Re-enchanting Primary Teachers and Science Teaching

Working together with the teacher, we were challenged, got confused and got excited. We had to learn and understand science to help us sort out problems we never knew we had at the start. Science not only served to challenge our thinking but reshaped and clarified it by offering an alternative perspective and more coherent and persuasive reasons. The process involved learning to play the game by another set of rules. With the force of more systematic and robust reasons, we got better at making moves in giving and asking for reasons. This process led to re-enchanting science, in the sense that planning and teaching science lessons were not just about teaching sequences, selecting activities or identifying key vocabulary. It became an expression and consequence of our thought and talk, our responsiveness to the role science played in our thinking, talking and understanding of the world. Through our discussions, the teacher not only had answers to ‘how’ questions, i.e., causal explanations for phenomena but became responsive to ‘why’ problems. As a result, she could appreciate a different way of thinking, talking and acting in the world. Science opened up an inferential space through which to think and talk about the world. When the teacher understood something, gained entitlements and acknowledged incompatibilities (e.g., the curvature of the Earth), she was so excited that she wanted to teach the lesson (see Epilogue for details).

Inferentialism described the systematicity of scientific thought and talk, which obscured our initial understanding but illuminated an approach that brought the concepts together as a systematic whole. The idea that these issues, which scientists engage with, are very much unsettled debates seemed to bring the topic and the spirit of planning science lessons alive. The notion that there was no single correct answer was liberating for the teacher and me in navigating the discussion. Of course, I am not claiming there are no right answers in relation to science. However, for the teacher, it ignited a fascination and curiosity that initiated a re-enchantment of nature, science and the topic. The re-enchantment was not of the scientific world but the nature of our world. The one in which we live, breathe and experience but animated by the force of reasons.

Here, I employ the term ‘re-enchantment’, drawing inspiration from Derry, who, in turn, credits fellow Pittsburgh neo-Hegelian John McDowell. Although she states that ‘McDowell has not actually spelled out what he means by “re-enchantment”’, she goes on to state that ‘it is clear from his writings that this must entail recognition that reason is a force in the world.’ (Derry, 2013a, p. 139). Further, in support of the spirit in which I used the term, she claims: ‘it is because there is a space of reason in nature that human beings are capable of grasping it by exercising their rational capacities. …The crucial move that McDowell makes is to argue that to be in touch with the world at all (as a human being) assumes a normative context.’ (*ibid*., p. 139). Scientific issues as a *space of reasons* and *normative* context, not only brought the force of reasons to bear on her reasoning but placed the responsibility of the classroom thought and talk on the teacher's judgments and responsiveness to pupils’ claims. It forced the teacher to avoid passive engagement of pupils with inert knowledge claims by attending to reasons that she became aware of, which I refer to as re-enchanting the science teacher.

What the concept ‘planet’ means from this inferentialist perspective that attends to historical and normative dimensions of its use and development is always up for debate as part of the continually shifting, changing and dynamic nature of dialogue within the scientific community. From an inferentialist perspective, the scientific enterprise is viewed as a continuous, dynamic and rigorous process of assessing and reorientating claims. This ongoing iterative process accounts for the complexity of the scientific enterprise, scientific terms, concepts and meanings. However, this is not to say that teachers can legitimately relegate scientific claims to being merely relative. For example, a teacher discussing planets may claim, inadvertently or perhaps with conviction, that ‘scientists are always changing their minds' as if it is akin to one preferred flavour of ice cream. However, this disregards the rigorous debates within scientific communities in reaching some relative consensus (e.g., Pluto). The critical inferentialist insight suggests that children are brought to appreciate and develop an understanding of a network of 'reasons' for scientific claims and presupposition. This contrasts with Mortimer and Scott's reading of Vygotsky, which emphasises distinguishing scientific language from everyday language. These reasons justify and explain why scientists use the language or vocabulary they do, by offering a more precise set of robust, coherent and persuasive reasons, in contrast to everyday thought and talk. Thus, teacher focus involves more than distinguishing scientific language, vocabulary or their use in classroom talk. Teachers should instead focus on the *reasons* and *systematic relations* that underpin the emergence, development and use of scientific language and their normalisation within science discourse. Teachers cannot rely on scientific language or defer responsibility to scientific knowledge claims to explain the world or phenomena. The teacher planning lessons is also responsible, and this requires on her part not only an appreciation of scientific facts but *practical know-how* in navigating the inferential network reasoned concept and orienting herself in the logical space that constitutes the scientific topic.

9.5 Chapter Summary

In many ways, the Earth and Space science topic readily offers an inferential system of concepts. The famous case of Pluto also served to illustrate the role of normativity as a function of historical and social development of concept meaning as part of a norm-instituting practice, a deontic practice. The vignettes illustrate the inferential role of concepts in norm-governed discussions and how having better reasons, in this case, scientific reason, allows one to play the game well. From an inferentialist perspective, if the teacher is to make concepts meaningful to children, it is not sufficient to challenge pupils' thought and talk. In responding to her pupils' claims, the teacher must make a more robust, coherent and persuasive case in her inferential moves in classroom talk. These moves within an inferential space of reasons arm the teacher with practical know-how, in the sense of knowing why scientific ways of thinking offer better reasons. It also involves acknowledging why scientific reasoning is not superior but always open, subject to change, revisions and updates. Scientific claims and knowledge offering better reasons are not absolute truths but serve as the norms that govern science classroom practice. In playing the game oneself and mastering moves, one begins to appreciate not only the science but the space of consequences. In making more persuasive moves, one remains open-minded and aware that the whole system may be updated, adjusted and reorientated- at any moment.

Coming to plan and teach science, background information or scientific facts are not enough. Teachers not only need to be responsive to pupils in the classroom talk, but responsive to reasons in planning and teaching, that is responsive to the space of reasons as both a space of implications and a space of possibilities. However, this responsiveness is not a given but involves some initial investment and development on the part of the teacher. Therefore, I turn to this issue of teacher development in my final illustration returning to materials.

10 Inferentialism and Primary Science Resources: Understanding Materials

This chapter serves as a capstone to preceding chapters, where I introduced and explained an inferentialist interpretation of concept-meaning and linguistic communication in reorienting an understanding of meaning-making. In the previous chapter, I discussed planning and teaching for the topic ‘Earth and Space’, exploring the role science concepts play within a holistic normative context or *inferential space of reasons.* In the following sections, I extend these inferentialist insights and propose ways in which they may further illuminate the practical challenges of classroom talk. In thinking about teaching and learning primary science I consider ways teachers could be better supported. I revisit the topic of materials in this chapter to consider how attending to the neglected inferentialist dimension has implications for teacher resources and their practice in teaching and learning science. I discuss and demonstrate how representationalism as a paradigm remains pervasive within teacher resources. In response, I propose inferentially-oriented practical resources with a view to supporting teachers in thinking and planning materials in primary science. These resources focus on developing teachers’ inferential reasoning in navigating materials as a normative space of reasons. With these concerns at the forefront of my mind, I turn to discuss the representationalist nature of teacher resources in teaching and planning science.

10.1 Representationalism in Teacher Resources

In working with a Year 5 teacher and school science lead, Ms Kapoor, we discussed her planning and preparation of her science lessons in detail. Our collaborative discussions, challenging our beliefs and commitments, talking and thinking through the scientific point of view, and developing appropriate justifications for our claims shored up and amplified our reasoning. The discursive process forced us to take responsibility for the science concepts we used, avoiding simply deferring our responsibility to the authority of scientists or the scientific community. In preparing for our discussions on both topics of Materials and Earth and Space, I collated and reviewed numerous primary science teaching resources. In the process, however, I became increasingly aware of how primary science resources approached scientific content as ‘background information’ (Australian Academy of Science, 2014) or as technical terms, vocabulary, or definitions to be addressed. For example, addressing concepts such as ‘hardness’ or ‘strength’ would be presented in terms of forces applied to them to explain its ‘mechanical properties’ (Wenham, 2005). As a result, I began to consider the role and use of these resources by primary teachers in planning and teaching primary science. I appreciate that this issue requires a systematic review of resources and an empirical study. However, as inferentialism offers an alternative approach to thinking about the meaning of concepts, I reflect on the nature of teacher resources viewed through an inferentialist lens. I contend that spotlighting the contrast between inferentialist and representationalist paradigms exposes how these inferentialist dimensions are neglected in theory, analysis, and practical teaching resources. This oversight, I argue, preserves representationalist constraints within the tools and resources used to support teachers in their teaching and planning practices. Furthermore, I suggest inferentialist insights in exposing the representational nature of teacher resources illuminate the challenges primary teachers face in classroom talk of primary science and begins to redress the emergence of theory-practice gaps in dialogic teacher development (see Chapter Three).

10.1.1 Representationalism Implicit in Teacher Resources

In primary teacher resources and approaches to teaching materials, there is a recognition of the crucial role language and its use play in the teacher's interpretation of children's learning (Cross and Bowden, 2014; Skamp and Preston, 2015; Loxley, Dawes, Nicholls and Dore, 2010). In line with MMF and dialogic teaching, a range of teaching strategies and classroom activities highlight the integral role of language use in 'facilitating conceptual development and change' in science classrooms (Skamp, 2015, p. 321). The teacher, therefore, needs to respond to planned activities and discussions accordingly. Various resources and researchers alert teachers regarding technical terms such as 'particles' or 'microscopic' and how pupils' use of scientific language may not reflect their own understanding of science (ibid., p. 321). There is a recognition that although children may correctly use technical terms such as 'particles', 'molecules', 'atoms' or 'CO_2', they may not be clear about their meaning (Liu and Lesniak, 2006; Skamp, 2015). Such terms and concepts in children's thought and talk could be 'misinterpreted' (Wiser and Smith, 2013). Subsequent recommendations in resources, make cautionary notes and remarks. For example, Skamp (2015) states: 'Teachers need to be *conscious* that students' language, apart from indicating their conceptions of how their world works, also may indicate what teachers need to introduce to advance thinking about phenomenon.' (p. 321 italics added). Thus, they suggest teachers need to proceed with '*caution*' and are urged technical terms such as 'objects', 'materials', 'substance' or 'pressure' should be used '***carefully***' (*ibid.*, p. 321). They need to appreciate the role of language in teaching, with 'an ***awareness*** that students' words may not always convey understanding will influence your conversations with them' (ibid., p. 322, italics added). The table below (See Table 25.) presents a selection of teaching resources I used with the teacher where I observed such claims. The sources and quotes show, albeit illustratively, the presence, role and use of representationalist language. The issue, viewed from the inferentialist paradigm, is how such cautionary remarks and statements are made as if they are self-explanatory to the primary teacher. As I consider Brandom's normative vocabulary, it offers a theoretical resource that allows researchers to make explicit and alert teachers to the representationalism within teacher resources. I argue that these teacher resources not only fall within a representationalist paradigm but further adopt a representational mode in supporting teachers.

Illustrative Table Summarising Representational Language

References	**Topic: Materials**
1. Teaching Primary Science Constructively (Skamp and Preston, 2015)	See the above examples.
2. Australian Academy of Science (2014a) 'Material World': Year 4 chemical sciences. *Primary Connections.* Canberra: AAS.	Science Inquiry Skills: Communicating 'Represent and communicate ideas and findings in a variety of ways such as diagrams, physical representations and simple reports' (p. 2)
3. Australian Academy of Science (2014b) 'What's the Matter?': Year 5 chemical sciences. Primary Connections. Canberra: AAS.	Science Inquiry Skills: Communicating 'Conveying information or ideas to others through appropriate representations, text types and modes' (p. vii)

4. Primary Science: teaching the tricky bits (Rutledge, 2010)	'The difficulties above can be often avoided by taking a few simple precautions. Chief amongst these is to pay careful attention to the language the children use.' (p. 20)
5. Essential Primary Science (Cross and Bowden, 2014)	The teacher are given scientific facts or explanations 'What the teacher needs to know and understand' (p. 223). The resource then makes the following claims: 'By upper Key Stage 2, pupils are expected to look at and test more complex properties of materials. For example, thermal insulators and conductors are investigated, as are strength and hardness and how these could be tested.' (p. 244)
6. Understanding Primary Science: Ideas, concepts and explanations (Wenham, 2005)	'Once the basic mechanical properties are distinguished and understood, and language is being used correctly, most if not all the difficulties can be resolved' (p. 104)

Table 25. Summary of representationalism in teacher resources

An inferentialist approach to knowledge claims redresses the issue of teacher resources by first recognising representationalist focus on language (linguistics) and language-use (pragmatics), or the *social language of science* (see Chapters Three and Four). Second, it involves reorienting an understanding of knowledge claims by focusing on the inferential role of concepts (concept-meaning, see Chapter Five) and the normative pragmatics of the science classroom discourse (classroom talk, see Chapters Six and Seven).

An inferential re-orientation of teacher resources would privilege the reasons and claim-making over vocabulary and utterances. Such resources would make explicit the inferential role of concepts in our reasoning, and the normative character of such reasoning articulated in our discursive practice in developing an understanding of thought and talk in science classrooms. Derry's professorial lecture (2018) entitled 'Knowledge in Education: why philosophy matters' explains this inferentialist orientation by addressing the role inferentialism plays in providing an alternative perspective on the nature of knowledge in educational matters. In introducing the problem of knowledge and education, philosophically, she illustrates her point by drawing inspiration from the life of renowned physicist Richard Feynman. She uses examples presented in the book 'The Pleasure of Finding Things Out', which is an 'edited transcript of an interview with Feynman made for the BBC television program Horizon in 1981' (2001, p. 1). In this interview, he discusses the experiment that earned him a Nobel prize, and '*why knowing merely the name of something is the same as not knowing anything at all about it'* (2001, p. 1, *italics* in original). He narrates how as a boy, a child asked him, 'What kind of a bird is that?'. When Feynman replied, 'he didn't know its name', the child who knew the bird's name began teasing him saying that his dad did not teach him anything. Feynman explains how his dad had taught him the name of the bird but went further to name it in several languages. However, his dad went on to explain that when you know the name of the bird in all the languages whatever names you know, he said, 'you'll know absolutely nothing whatever about the bird. You only know about humans in different places and what they call the bird.' (2001, p. 3), followed by 'Now,…let's look at the bird.'. Derry uses this example to illustrate how Feynman took issue with knowing the name as constituting knowledge or understanding. In talking about Feynman, Derry states:

> 'It was as though he was only interested in meaning, in what connects names with each other, how they function, but not what label is given to them. It

seems that his interest lay in how words come to stand for what they represent. Although he recognized that knowing the name of a phenomenon is necessary for communication, his focus was elsewhere.' (2018, p. 2).

Derry further clarifies, 'Feynman understood that the meaning of words and concepts can only be understood through relations.' (ibid., p. 2). She goes on to argue how these relations are inferential relations that constitute the meaning of words and concepts in our discursive practices (see Chapter Five for details). Similarly, I illustrate my inferentialist point regarding teaching resources and science classrooms with a vignette inspired by Feynman's work with school science textbooks. Developing this illustrative example, I revisit the classification of materials to discuss the potential implications of inferentialism for teacher resources and practical implications for classroom teaching and talk.

10.1.2 Feynman, Textbooks and the Inferential Mode

A compelling case for the inferentialist argument regarding school science textbooks is illustrated in Feynman's life. In his autobiography (Feynman, Leighton, Hutchings, 1997), he narrates an incident while serving on the Board of Education to review school textbooks in mathematics and science. I share a short vignette here of his review of a science textbook. He reviewed a textbook activity with several pictures: a wind-up toy, a car, a boy on a bicycle, and some unspecified fourth. Each image was accompanied by the same question, 'what makes it go?'. Feynman assumed he understood where the resource was going. The wind-up toy would relate to the mechanics of springs, the car with chemistry related to the internal combustion engine and fuel and the boy would relate to biology and the contraction and relaxation of muscles. He expressed these ideas the way his father did when he asked Feynman: “What makes it go? Everything goes because the sun is shining.”. He recounts that as a child, he would constantly ask why. Why does the toy go? His dad would reply, ‘because the spring is wound up’. How did the spring get wind up? Dad responds, ‘because I wound it’. He went on answering that he can move and wind the toy because he eats, and ‘food grows only because the sun is shining’. So, all things move because the sun is shining. There was a whole network of relations, a coherent conceptual system, that wired up all the ideas systematically to help to make sense of the claim ‘everything goes because the sun is shining’. For Feynman, his conversation with his father allowed him to understand how ‘motion is simply the transformation of the sun’s power.’ (ibid*.,* p. 296). However, contrary to Feynman’s expectations, the textbook told a different story. For every image, the answer was the same. What makes the toy go? ‘Energy makes it go’. What makes the car go? ‘Energy makes it go’ and so on. The problem, as Feynman explains, was that such an answer ‘Now that doesn’t *mean* anything’ (ibid*.*). The term or concept does not provide any access to what is being said or explained. He claims ‘energy’ could just as well be replaced by a nonsense word such as ‘Wakalixes’ (ibid*.*). Furthermore, he states, ‘There’s no knowledge coming in. The child doesn’t learn anything; it’s just a *word*!’ (ibid*.,* p. 296). This inferentialist perspective relates back to Derry’s argument that although names may be necessary for communication, they do not by themselves constitute knowledge, meaning or understanding (2018).

Following his reported horror, Feynman proposes a different approach that looks at the wind-up toy as a way to learn about the springs and the wheels and other conceptually related ideas and ‘never mind “energy”’ (Feynman, Leighton, Hutchings, 1997*,* p. 296). He recognises how the more ‘general principle’ of energy, although an overarching concept, can be introduced later once children ‘know something about how the toy actually works' (ibid., p. 297). Feynman's orientation to the systematic relations of the knowledge domain makes him sensitive to the inferential role concepts play in thought and talk and their incompatibilities. As exemplified in his criticism: 'It's also not even true that "energy makes it go," because if it stops, you could say, "energy makes it stop" just as well' (ibid.). Having an inferential orientation to the knowledge domain as a *space of reasons* for making and responding to scientific claims, he understands not only the intention of the author but also their limitations, as exemplified when he clarifies their limitations by stating:

> What they're talking about is concentrated energy being transformed into more dilute forms, which is a very subtle aspect of energy. Energy is neither increased nor decreased in these examples; it's just changed from one form to another. And when the things stop, the energy is changed into heat, into general chaos. (Feynman, Leighton, Hutchings, 1997, p. 297).

Feynman, himself a science educator, exemplifies being inferentially oriented to the knowledge domain. His practical mastery of applying concepts enables him to play the game well. This grasp of the systematic relations that hold between concepts and claims, the logical inferential relations, allows him to assess textbooks he reviewed. This practical mastery of applying concepts leads to his comment about textbooks, 'They said things that were useless, mixed-up, ambiguous, confusing, and partially incorrect. How anybody can learn science from these books, I don't know, because it's not science.' (ibid.). Let me be clear I'm not suggesting primary science resources are useless, confusing or 'not science'. Feynman's work was conducted over half a century ago, under different conditions and contexts. My aim here is to illustrate how introducing teachers and researchers to inferentialism offers an alternative perspective on the nature of scientific knowledge and classroom discourse. Consequently, I aim to illustrate that from an inferentialist view, what makes a claim or thought ‘scientific’ lies not in words, vocabulary or language used but in the systematic relations between claims or reasons articulated in thought and talk. I am not suggesting that technical vocabulary or scientific language is to be dismissed out of hand. However, I suggest inferentialism offers an alternative to representationalist approaches by privileging the conceptual system or systematic relations governing the correct application of concepts, which is determined by their inferential role within a knowledge domain. It recognises expert teachers' responsiveness to the logical space of reasons in discursive practices.

10.1.3 The Inferential Role of Classification

A fundamental contribution of the inferentialist orientation lies in its distinctive normative vocabulary. This innovative vocabulary makes explicit the inferential dimensions of theoretical and practical judgements teachers and pupils make in teaching and learning science. It highlights teachers' autonomy in making judgments and taking responsibility for making such practices or activities meaningful for both the teacher and the learner. This involves understanding the teacher’s commitments, her awareness of entitlement and incompatibilities in her practical mastery of concepts. This inferential awareness underpins her responsiveness to children’s claims and commitments. The teacher needs to have a robust conceptual grasp or mastery of the similarities and differences in the appropriate role the concept plays in thinking and talking about science. This, in turn, allows the teacher to rethink her practical approach to classification not only in making explicit the inferential role of classification activity, but the role it plays in coming to think about and understanding materials as a concept. In tackling these demands on the primary science teacher, the following section explores an inferential-oriented approach to developing teacher resources. I focus on the reasons in thought and talk that constitute the role and meaning concepts play in practical and discursive activity. In discussing teacher resources, classroom activities and how teachers reflect on engaging children's own thinking about materials and their properties in classroom talk, I revisit the classification of materials (see Chapter Five).

10.2 Classification of Materials Revisited: Inferential Teacher Resource

I propose developing inferentially-oriented resources to redress the representationalism in teacher resources. Earlier (see Chapter Five), I introduced card statements and card-sorting to modify the classification activity as an inferential activity (See §5.4). I aim to further modify that classroom activity, taking inspiration from McCrory's (2015) inferentialist work developed within history education, to develop resources for primary teachers. Below (see Table 26.), I summarise my earlier modifications of the classification and proposed extension. In thinking about teachers' understanding in classifying materials, the resources introduce weighting of teachers' judgments, followed by a worksheet that demands justification. I suggest these resources alert teachers to the *normative space of reasons*. This in turn offers opportunities for teachers to develop an inferential orientation to the primary science knowledge domain and discourse.

Inferential Teacher Resources for Classification of Materials

Classroom Resources (Chapter 5)	Practical Tasks
Step 1: Initial Classification Activity	Classifying (Objects and) Material within Venn diagram
Step 2: Introducing Statement Cards	Task A: Sorting Statement Cards Task B: Classifying Statement Cards
Teacher Resources for Classification	**Practical Tasks**
Step 3: Introducing Circle Sizes	Task A: Judging Appropriate Circle Size
Step 4: Worksheet	Task B: Assigning Circles to Worksheet

Table 26. Inferentially-oriented teacher resources

10.2.1 Step 3: Circle Sizes as Weighted Judgments

The first additional step involves introducing an assortment of differently sized circles as a new resource (see Fig. 25.). The additional task requires the teacher to sort materials or statement-cards within the Venn diagram. However, it also involves them in selecting and assigning circle sizes for relevant and appropriate classification categories related to the material (see Fig. 26.). So, what are these circles, and what purposes do they serve?

Materials and Circle Size Resources

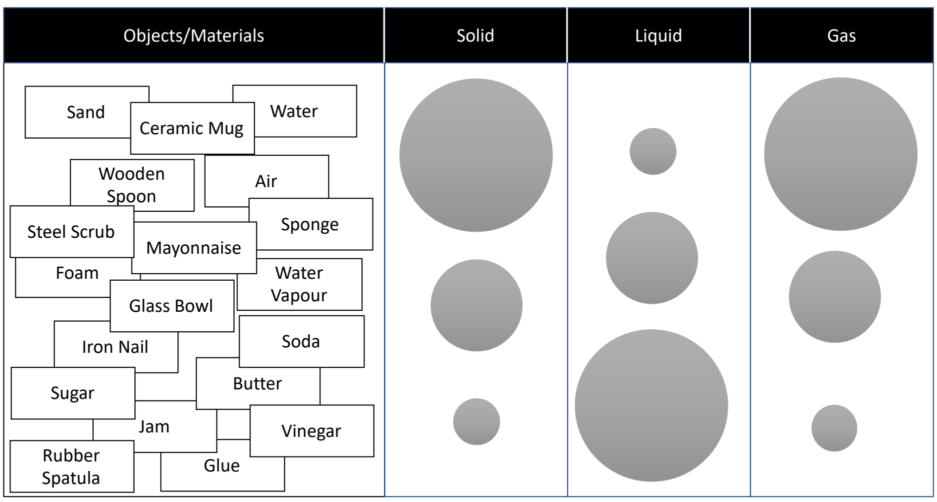

Fig. 23. Circles sizes introduce weighting of judgments, which requires justification

Each of the three classifications: solids, liquids, and gases, corresponds to a selection of three circle sizes (small, medium, and large). These differently-sized circles serve as a resource in extending the classification process (see Fig. 25. Above and Fig. 26. below). The circle resources provide a means for making implicit teacher judgments, visible and available on the social plane, for comparison, discussion, and critical evaluation by peers, expert teachers or more knowledgeable others. In contrast to the Venn diagram classification, determining and assigning circle sizes, makes their judgments open to critical assessment. The activity forces teachers to take *responsibility* for their judgments with reasons rather than by uttering a statement or an act of classification. From an inferentialist perspective, any activity, practical or theoretical, involves undertaking a responsibility, making a commitment and being held accountable by others. One is taking responsibility in playing the *game of giving and asking for reasons* as a legitimate player. A player could defer one's responsibility to some knowledgeable other or community, e.g., scientists, scientific community, or facts. For the expert teacher, inferentially oriented to the knowledge domain, scientific knowledge or claims are not a 'given' or 'inherited' (Loeffler, 2018) but a rational responsibility. Each and every claim is a rational judgment underpinned by a constellation of premises that expresses a conclusion, which itself may serve as premises in making further claims and conclusions (inferential reasoning). Classifying materials, interpreted as an inferential activity, as making judgements in norm-governed practices, involves a network of commitments and entitlements, that is, reasons for undertaking specific commitments, and making certain inferences and assertions. As a player of the game, in making a move in classification, one should be able to justify one move in being challenged by giving reasons as a player of the game and participating in discursive practice. The circles by themselves do not achieve this but it serves to initiate that game. Teachers' justification and reasons for their judgments and claims are made explicit in the final step in developing teacher resources – which is introduced via the worksheet (see Fig 26.).

10.2.2 Step 4: Worksheet- Which Size Circle for Which Properties?

The worksheet foregrounds the role of reasons underpinning teachers' judgment (i.e., inferential reasoning) and further calls on them to justify their reasoning according to the rules of the games, i.e., scientific knowledge. For example, a wooden spoon may be classed as solid rather than a gas. While one may justify this move in various ways, there is a coherent and logical network of reasons appropriate to scientific thinking and justification. The systematicity and coherence of such scientific reasoning (logical space of reasons) become more evident in the case of difficult-to-classify, obscure, complex materials, such as sand, jam, hot water, or foam.

Circle Size Worksheet: What size for which properties?

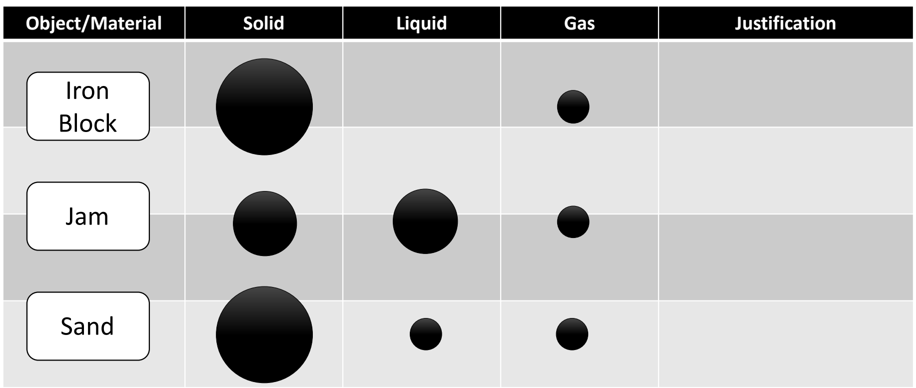

Fig. 24. Circle sizes and teacher worksheet

The struggle to classify more complex materials challenges one's presuppositions or commitments, and entitlements are endorsed through thinking and discussing materials and their properties. Surely, a piece of iron is not equally solid as it is gas because of smell, or is it? Consider Jam; it displays solid, liquid and gaseous properties, is it to be located at the central intersection of the Venn diagram? Do most materials essentially end up in the middle of the Venn diagram? Such issues remain ambiguous in using the Venn diagram and other representational approaches as a self-contained activity. These representational classification systems or diagrams are not self-explanatory. As representations, they do not themselves offer reasons for correctnesses and incorrectness of moves, nor can they be readily read-off from the classification of materials or statement cards in isolation. Correctnesses and incorrectness of claims or judgments are for Brandom normative issues; their appraisal depends on the rules of the game, involving a *normative appraisal* and *responsiveness* to the *logical space of reasons*. These rules and moves in playing the game are what (rationally) inform and (normatively) constrain the teacher's approach and selection, informing the planning and teaching activity. The worksheet serves to induct the teacher into the *normative space of reasons* by developing a particular responsibility. In developing responsiveness to the norms governing the use of concepts articulated in thought and talk of classification, the teacher develops a practical mastery in using concepts. A teacher responding with reasons is aware of the norms governing scientific inferences and discourse. She would be receptive and respond to a more systematic, robust and persuasive set of reasons that justify the classification of more fuzzy materials such as foamy wood, sponge, sand or fizzy drinks.

In presenting the orientation of resources inferentially, I suggest they foreground the role of teacher judgments and reasoning that remain implicit in representationalist approaches to practical activities. The resources would not only engage teachers' thinking and commitments. It also alerts them to entitlements in thinking and talking science of materials and the precision and systematicity of the role concepts play in scientific thinking. The central point to acknowledge is how inferentialism privileges the role of the inferential over the representational in an account of language, concept-meaning and communication. It is judgment as inferential reasons that are the fundamental unit in an explanatory account of meaning-making. These inferentially related reasons manifest in children's and teachers' believings, sayings and doings. In short, the resources offer an inferential route for teachers to acknowledge ways to induct pupils into the *logical space of reasons* of science. I illustrate these resources by discussing the case of classifying sand.

10.3 Classification and Teacher Judgement: The Case of Sand

I work through the inferentially-oriented resources using the example of sand to provide an inferentialist commentary. I begin by contrasting two teachers' responses to classifying sand and the resources. Placing materials within a classification system (e.g., Venn diagram) already expresses background presuppositions and inferential judgments. So, while the teachers may classify sand under the same categories, they may do so for different reasons. The worksheet forces teachers to articulate their reasons in ways that justify their classifying moves and assigning of circles. This activity serves to differentiate their commitments and entitlements. I provide two fictitious examples for comparison below.

Comparison of Worksheets: Two Teachers' Classification of Sand

Teacher A: Mr Amin

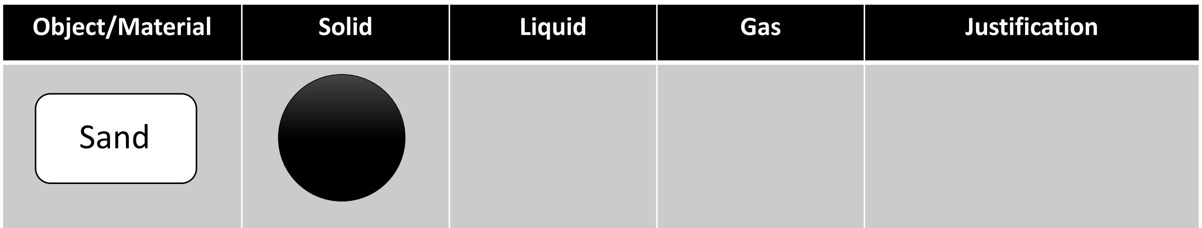

Fig. 25. Mr. Amin's circle selection in classifying sand

Teacher B: Ms Kapoor

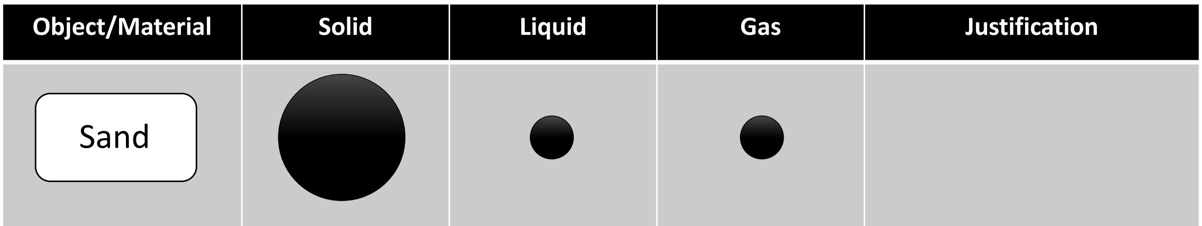

Fig. 26. Ms. Kapoor's circle selection in classifying sand

Mr Amin classifies sand solely as solid. He assigns a large sized solid circle to sand, justifying his classification and circle assignment expressed as follows:

> "Sand is a granular material composed of parts. Although you can put your hand through it or pour it, when viewed at the granular scale, it is a collection of grainy bits. At this microscopic scale, the constituent parts of material can be subjected to forces and changes that display mechanical properties such as brittleness, roughness, hardness and lack of compression observed on a larger scale at the bulk level. Although sand can be poured, it is not a liquid because it is not wet or runny. So, it should be classed under a solid." -Mr Amin.

Mr Amin, following a more discrete classification[100], reduces sand to the single category solid. The object and material are identified with much smaller grains, which are 'hard' and can be 'crushed', 'handled' and many other properties that are attributed to the category solid and thus justify the classification of the material as 'solid'.

Ms Kapoor, in comparison, makes a somewhat more counter-intuitive classification by including both liquid and gas. While one may wonder how on earth sand is a gas, scientific ways of thinking are often counterintuitive. For example, different masses fall at the same speed, a snowman in thick jacket melts slower or keeping windows closed during a heatwave keeps the room cooler. Now, while materials scientists and engineers are aware that sand is not a viscous substance, its fine granularity serves to display 'granular flow', a property typical of fluids. However, engineers at MIT in recent studies provided an empirical account and equations that describes the movement of sand particles dispersed in the air, that is describing its gaseous property. Ms Kapoor's answer and justification suggest she is privy to such scientific developments. However, it follows as an extension of her ability to recognise that although sand does not display all the empirical properties of liquids, it still displays a select few, such as flow and everyday descriptions such as pouring. She understands sand as a material that is not in a liquid state, but may still display some 'liquidy' properties, and therefore may be classed to a certain extent under 'liquid'. Her conceptual understanding (inferential commitments) allows her to easily update her commitment and entitlements to amplify her thinking to include and permit gaseous properties. As an expert teacher, Ms Kapoor is responsive to

[100] The teacher here, in following Allen's advice, construes sand as liquid as a 'misconception', which understood in scientific terms is in fact a solid.

thinking through the concepts that emphasise *why* something is solid and, say not a liquid. More importantly, she is aware of the compatibility and incompatibility relations in justifying such claims and responsive to the norms of discourse that constitutes her scientific thinking. Even though she may use technical terms, she remains responsive to a systematic network of claims and reasons that animates and justifies her classification of different materials. Her justification statement could be articulated as follows:

> "Sand is a granular material. It is made up of tiny grains, which display the empirical and mechanical properties of a solid. However, the scale and granular size are critical factors. At large scales, sand's bulk properties and behaviour as a material are important in industrial processes such as flow and dispersion. However, it does not display essential empirical fluid properties such as viscosity or compressibility but displays granular flow. Overall, sand displays more solid properties and few liquid or gas properties limited to the macroscopic or industrial scale. Cutting-edge science has shown ways sand can be considered as displaying liquid and gaseous properties in relation to their movements due to its granularity." – Ms Kapoor

Ms Kapoor not only understands where to place sand within the Venn diagram. She is also aware and responsive to the role concepts such as 'solid', 'liquid' and 'gas' play in thinking and talking about materials and their properties at various scales using various descriptions. In making theoretical and practical judgements, she does so with an awareness that the appropriate application of scientific concepts allows her to understand what should and should not be said or done. She is responsive to the norms of scientific discourse, which not only justifies her commitments with reasons but also entitles her to them in more robust, coherent and persuasive ways than articulated by Mr Amin. Classifying sand as a solid, Mr Amin acknowledges sand can be poured. He justifies his classification based on measurable solid properties, while sand fails to display empirical properties of liquids or gases. Ms Kapoor adopts a more nuanced view, recognising solids, liquids and gases are not exclusive states nor identified with a location within a representational diagram. She acknowledges certain ‘properties’ sand displays viewed from different perspectives. From everyday descriptions and observations at the macroscopic level, sand displays certain fluid-like properties, like pouring, flowing and even dispersing like gases. Thus, sand displays certain ‘liquidy’ and ‘gassy’ properties, assigning circle sizes and acknowledging that these categories are not exclusive states but inclusive properties. She nevertheless understands such displayed properties does not entail empirically measurable fluid properties such as viscosity or compressibility when the material is at rest. As such, she assigns smaller circles to these properties (i.e., liquid and gas). Ms Kapoor classifies sand with an inferential orientation to the knowledge domain. Her understanding extends beyond merely acknowledging sand as a granular material. She is also responsive to the reasons that relate to how other complex and obscure materials or ‘boundary materials’, such as iron, jam, aerosols or water vapour, behave under typical classroom conditions.

10.3.1 Classifying Materials: Teacher Judgments as Normative Authority

The classification of sand is a judgment. For the expert or inferentially-oriented teacher, classifying sand is not just a practical act of placing sand within a classificatory system. It also involves placing one’s claim or concepts within a conceptual system or, in inferentialist terms, a *logical space of reasons* (Derry, 2013a, p. 73)**.** This placing as a judgment is an inferential activity. In primary classrooms, these practical activities function under the constraints of the knowledge domain of science. The constraints are the rules that govern and authorise thought and talk; reasoning and discourse of science, in being able to justify or give reasons for why a claim is legitimate or permissible in playing the game. When discussing materials in the classroom, for example, it is essential to know what is appropriate or inappropriate in classifying materials. The critical inferentialist point is the significance of being responsive to the interrelated reasons for *why* specific classifications are appropriate or inappropriate. For example, it involves being able to justify one's judgments expressed in classifying sand. In appreciating the reasons that justify the appropriate ways of thinking and talking, the teacher can begin to grasp what is assumed in making scientific claims and using science concepts in science classrooms. In thinking about teacher autonomy and differences in teacher judgment and pedagogy from an inferentialist perspective, as illustrated with Mr Amin and Ms Kapoor, Derry articulates a valuable insight claiming:

> Understanding pedagogy as a process of adjusting the connection of ideas already known but connected differently is quite different from a familiar conception of pedagogy as an approach consisting of techniques and style. Vygotsky makes the point that two people can appear to have the same level of knowledge but in fact differ widely. (2013, p. 96).

In classifying sand, the teacher acknowledges specific commitments and entitlements, that is, her own inferential reasoning about sand and materials more broadly. The inferential resources engage teachers in making their assumptions and beliefs, or inferential commitments explicit, for themselves and others. In contrast, the actualisation of the teacher's authority derives from her responsiveness to the norms governing the knowledge domain. Being held accountable for one's thoughts, talk and actions and being able to justify them. One becomes responsible for inferences and claims made in thought and talk. In justifying claims, a teacher's capacity to discern what one is or is not entitled to say or do, allows her to make appropriate judgments for the appropriate reasons. The teacher's judgment in rationally and conscientiously discerning claims indicates the extent of her authority in a given knowledge domain. In inferentialist terms, the critical distinction between Mr Amin and Ms Kapoor is accounted for by their *responsiveness to reasons*. The teacher's ability to justify classification in navigating the systematicity of knowledge domain and concepts without deferring responsibility to so some other authority or retreating to an external vantage point is her authority in normative terms. This normative authority is the teacher's responsibility in responding to norms as reasons in thought and talking with her class. The inferential resource illustrates how representing differences in classroom talk or communicative approaches is not sufficient for teachers. What is required is inducting them into the logical and normative space of reasons. In becoming responsive to the rules of the games, that is the norms of scientific reasoning and discourse, the teachers begin to develop a normative authority in thinking and talking science.

The inferentialist resources stress the need to explain the nature and development of this authority in teaching practices in terms of playing the game of *giving* and *asking* for *reasons*. An inferentialist account of Ms Kapoor's authority is explained by appealing to her judgments and her ability to *respond* to moves in the game of giving and asking for *reasons* in accordance with the norms. The expert teacher in discursive practices, playing the game, makes her moves with an awareness of better, that is more coherent, persuasive and robust reasons. An inferential orientation to the norms governing the knowledge domain allows her to be more responsive to (better) reasons in classroom discourse. For example, 'sand is a solid' is not merely justified because it is hard and incompressible. Although this may justify excluding it as a gas, as Mr Amin concludes, the expert teacher is aware this is not a logical entailment. A teacher's normative responsibility in practical and theoretical reasoning is underpinned by her inferential orientation in navigating the normative space. Her inferential orientation to terms of 'solid' and 'gas' as co-present *properties* of material, as opposed to discrete states of matter. This acknowledgment enables her to recognise the compatibility of claims that may seem contradictory. For Ms Kapoor being classed as a solid does not immediately exclude it from being a gas. She also recognises conflicting claims and critical reasoning that allows her to ensure her claims and reasons are coherent, robust, and persuasive. In other words, this *logical* space of reasons, and its systematicity constitutes the norms governing the scientific discourse. In proposing the above resources, I sought an approach that would alert teachers to the norms and their inferential responsibility. My aim was to offer an approach that avoids simply deferring responsibility to teacher *reflection*, which leaves the norms and reasons in classroom talk and practices implicit.

10.4 Teacher Responsiveness in Science Classrooms

10.4.1 Classification as Normative Constraints

For most primary teachers, the role and function of classifying materials in scientific terms are not a given. They are likely yet to develop such awareness of the rules implicit in the game and responsiveness to reasons for making appropriate moves. Although selecting and distinguishing 'simple' and 'complex' materials may seem obvious to the scientifically minded, what is entailed by such ideas may be far from obvious for the non-specialist primary teacher. For example, in my fieldwork, a particular pedagogic challenge emerged in planning for classification. As we discussed using the Venn diagram and introducing 'simple' materials moving toward more complex materials; we selected sugar, treacle, and jam. In thinking about more complex materials, we discussed objects that would class as all three categories. Pizza certainly fits the bill, as it displays all three properties, solid, liquid, and gas. However, pizza as an object consists of several materials. A key but implicit rule in selecting materials for classification involves an understanding that the objects or materials introduced into this activity at this stage, even if they are 'complex materials', should nevertheless be a singular and uniform material. Pizza is not a singular material, unlike chocolate, butter, jam or sugar and subsequently constitutes a somewhat more complex object. In planning and teaching for classification and selecting materials, the teacher should be aware of how concepts (e.g., solid, liquid, gas) function in relation to other concepts. She should be aware of its inferential role in undertaking an activity and in developing an inferential awareness of the rules and moves in playing the game (e.g., classification).

Various primary science resources highlight an overarching context, theme or integrated activities that form part of a scientific narrative. Following such resources, the inferentialist point is that selecting materials for classroom activities and teaching sequence all involve teacher *judgment* and *responsibility*- an inferential awareness and normativity authority. A slice of pizza, for example, may not immediately pose a problem in being selected for classification within a Venn diagram. It would be appropriate to locate it at the intersection of all three circles. However, as with sand, classification is not simply a button-sorting activity, reduced to merely placing items in the appropriate space (McCrory, 2015). Selecting pizza as an item involves grasping its inferential role and consequences within the topic and not just classification. The teacher must be aware of the complex issues that may arise while undertaking the activity and subsequent classroom discussions as operating within a space of implications. She needs to be responsive to reasons, in the case of pizza, reasons that differentiate the properties of the object (pizza slice) and materials constituting the object (pizza dough, tomato sauce, vegetables, cheese and so on). The norms of the knowledge domain constrain what is said and done in the classification activity and the science topic more broadly. The expert teacher not only recognises the limitations of selecting pizza in classification but may be able to capitalise on specific opportunities these challenges offer. Pizza as a complex object, made of multiple materials, displaying various properties, make it ill-suited to the role of classification of materials. Alternatively, if the teacher can recognise the complexity of this example, she may recognise and utilise the *inferential space of reasons* it offers. As a complex object, it immediately draws on other ideas, concepts and claims that may be utilised in teaching materials. Pizza is made from several ingredients, which may be solid, liquid or a mixture. These ingredients may be viewed through the solids, liquids and gases framework and utilised for classification.

Making pizza provides a holistic and inclusive context for teaching materials. All the various ingredients and cooking utensils offer the teacher opportunities to develop classroom discussions around solids, liquids, and gases. There are sauces, flour, salt, and butter. Eggs and whisking provide for mixtures (Wickham, 1997), reversible and irreversible changes[101]. Making the pizza dough would introduce discussions on the mixing of materials. However, the resultant dough would demonstrate irreversible changes while displaying properties such as stretching and elasticity. The process of making the dough involves various applications of

[101] Other sundry items as part of the meal could also be included such as mayonnaise, which could open discussions on emulsions (Ogborn, 2004).

mechanical forces, kneading, rolling out. In the final stages of baking the pizza, the chess melts, the dough hardens, and the chemical changes could be used to move classroom discussions on from physical changes. The hardness of the dough, melting cheese and gaseous properties related to the aroma offer a space in which the teacher could transition between various aspects of the topic as a whole. This inferential space could be used to make explicit the inferential role of the concepts of materials, properties and classification within a holistic, practical, and norm-governed context.

The example can be extended from objects, materials, properties, and physical changes through to reversible and irreversible changes. The critical inferentialist insight is that neither the selected materials for classification nor the teaching sequence are by themselves sufficient in leading the thought and talk of the science classroom in teaching about materials. Science teaching and classroom talk require recognition of the relevant reasoning and *responsiveness* to the rules of the game in play. I suggest that inferential resources serve to alert the teacher to the role normative constraints play in teaching. It also supports teachers in developing an awareness and inferential orientation to the norm-governed inferential relations that not only inform the teacher's approach to planning but constitute her normative authority and responsiveness to reasons in classroom activity and talk.

10.4.2 Responsiveness to Reasons in Classroom Talk

Understanding the nature and complexity of materials is not simply a matter of knowing the ‘scientific facts’ or having ‘Teacher background information’ (Australian Academy of Science, 2014a). The previous chapter and the resources presented above illustrate how inferentialism foregrounds reasons and norms in reorienting our understanding of what is involved in grasping a concept. The development of concept meaning through playing the game of giving and asking for reasons is interpreted not as a psychological affair but as a strictly non-psychological affair (Derry, 2020). Discursive reasoning articulated in our thought and talk in social and norm-governed discursive practices embodies the development of meaning and conceptual understanding.

The inferential resources spotlight how a network of reasons permits or authorises an object or material to be classed under a particular category, as opposed to mere technical knowledge of a collection of facts or statements, background information or a ‘knowing-that’. An Inferentialist view involves coming to appreciate how any concept involves a great many concepts. Concept meaning is related by systematic relations or *reasons* that serve to justify other claims or commitments. For example, in using the concept solid and grasping its meaning, one can conclude a material is solid and subsequent inferences that follow from it – a practical mastery, or know-how in applying a concept in discursive practice. The correct application of a concept in norm-governed practices involves *knowing why*, that is, rational judgments and a normative authority (Brandom, 2001; Derry, 2013b). The worksheet justification boxes force teachers to place their claims within a *logical space of reasons* and locate assertions within an inferential network. The worksheet in eliciting justification makes their judgments and inferential commitments explicit. This opens up their assertions to normative assessment by others who are responsive to reasons and norms of scientific discourse. The resources and activity thus lie not in simply having one’s own reasons but in developing specific responsiveness to *better reasons* in justifying and being held accountable for one’s claims. In making claims and judgments, one has a responsibility to justify in more systematic, robust and persuasive ways why those reasons are better (logical space of reasons) in discursive practices or classroom talk.

An inferential interpretation of classroom talk in attending to the normative dimensions of our discursive practices foregrounds the reasons articulated in teachers' interactions with children. The dynamics of this exchange, this *game of giving and asking for reasons,* in the science classroom are led first and foremost by the teacher, her judgements, authority and responsiveness to the norms governing what is said and done in classroom activities. An inferentially-oriented teacher acts on her own commitments and entitlements and makes conscientious judgments in responding to the pupils' claim-making as part of her inference-making capacities. In assessing and challenging a child's reasons, the teacher can begin to calibrate the child's reasons. Further the teacher can relate pupils' thinking and talk to the network of reasons. In doing so she can begin to *assess, challenge, endorse and calibrate* the thought and talk of science concept-use with children as an inferential mode in teaching science. From an inferential perspective, it is not the 'talk' that is central to an explanatory account of the quality of dialogue but the teacher's judgment, as someone who is responsive to reasons. This view is opposed to linguistic representations, which neglect the role of teacher judgments as part of norm-governed practices of giving and asking for reasons and discursive reasoning. In an inferentialist orientation to thought and talk in science classrooms, it is not the classroom talk that needs to be made visible to teachers. Inferentialism requires making explicit the expert teachers' responsiveness to reasons articulated in classroom talk. Their normative authority is embodied in teacher's responsiveness to pupils' thought and talk. Inferentialism in privileging the articulation of reasons in norm-governed practices, shifts the focus away from the representation of classroom talk, and as sufficient in supporting teachers in their practice. The inferential resources aim to offer the teacher the opportunity to develop responsiveness to reasons in discursive practices. In other words, a practice-based approach offers teachers an opportunity to develop responsiveness to the norms governing discourse and activities in the classroom. In engaging in dynamic and ongoing discursive practices, both me and the teacher in articulating our inferential reasoning, in playing the game, came to express and acknowledge our commitments and entitlements.

10.5 Summary Comments

In sum, this chapter illustrates how it is not enough to provide teachers with scientific facts, content knowledge or ‘background information’ supplemented by practical activities or resources (e.g., classification). From an inferentialist perspective, promoting meaningful understanding and communication involves not just coming to use concepts or participating in scientific discourse in more appropriate ways. It involves becoming responsive to norms (rules) and constantly calibrating reasons, updating commitments articulated in thought, talk and classroom activities (scoring moves) in playing the game well. Developing this capacity (inferential awareness) and ability (normative responsibility) involves resources that induct teachers into the normative space of reasons constituting the knowledge domain of the science topic, for example, Materials or Earth and Space. It also requires providing teachers with adequate opportunities to not only rehearse ideas through participating in the social language of science but also to protect them from slipping into representational modes in classroom interactions. I suggest providing resources that develop a practical mastery and normative authority in playing the game and getting better, allowing them to access an inferential mode in their teaching. In chess, for example, one does not become a master by accumulating chess strategies or imitating or watching games. While these may be useful, more crucial is to be able to play the game oneself; by being challenged and getting better at playing well. Such practical mastery is an indicative mark of an expert player or teacher, responsiveness to reasons as part of a norm-governed network of inferences and implications.

I contend that such inferential resources alert teachers to the inferential structure, making accessible the normative constraints and semantic responsibility in assessing permissible or impermissible claims in scientific discourse or science classrooms. This inferential inversion in explanatory strategy allows one to express pedagogic ‘care’, ‘awareness’, and ‘attention’ in terms of the inferential structure of conceptual content (semantics) and their use as normatively constrained by the space of reasons (pragmatics). It acknowledges language, concepts and communication as always already conceptual, involving reasons, judgements and norms that govern their expression in classroom thought and talk. Thus, the teacher can become increasingly more responsive to norms constituting the knowledge domain and discourse and to the reasons articulated by her pupils. The teacher undertakes a normative appraisal of the correctnesses of claims concerning the domain knowledge (disciplinary facts). She does this with a specific authority in challenging, endorsing, correcting, or calibrating children’s inferential reasoning articulated in classroom talk and activities. Thus, her ability and responsibility to track and trace the score of the game for each player constitutes not only an authoritative approach in linguistic communication but her normative authority in playing the game. A pivotal claim in Brandom’s inferentialist account of our language, concepts and communication is that these issues, our social practices, are all to be understood as being fundamentally a matter of normativity and a story in which ‘it is norms all the way down' (Brandom, 1994, p. 625). Therefore, an inferentialist explanation of meaningful understanding in teaching and learning viewed as a human affair is considered a fundamentally normative affair. It is underwritten by our reasoning and responsibility, that is our responsiveness to reasons in playing the game of giving and asking for reasons. There is no vantage point outside our reasoning, judgments and reason-giving and reason-asking practices. This chapter focused on discussing the role of norms in teaching practice and classroom talk, illustrating how Brandom's normativity functions on three interrelated levels that run all the way through from planning to talk. First, as illustrated in Earth and Space, the knowledge domain constitutes the norms governing the correctnesses and use of science concepts, claims and practical actions in the classroom. Second, the inferential and normative relations that constitute these norms of science classroom discourse constitute the teacher's authority in using science concepts appropriately and awareness of how a concept should or should not be applied in thought and talk. This practical mastery and conscientious discernment on the teacher's part informs the third and final level - the teacher's normative assessment of classroom talk. This assessment involves the teacher's responsiveness to reasons articulated in what pupils say and do in the classroom. Her response entails normative responsibility in calibrating pupils' thought and talk, inducting them to become responsive to the norms of the science classroom (i.e., space of reasons).

In focusing on teachers and resources, the aim was to develop an appreciation of the central role of the inferentialist concept of space of reasons in teacher judgments and classroom practice that runs in line with lesson planning through to classroom talk. Both the teacher and pupils, in taking responsibility and being accountable for what they say and do and mean, develop responsiveness to reasons and wield practical mastery in becoming ever-better players in the ongoing human, rational and discursive practice of scientific discourse.

11 Conclusion and Implications

Although the present study started as an empirical investigation, it gradually developed into an in-depth theoretical analysis and became a philosophical critique. In getting to grips with Mortimer and Scott's meaning-making framework (MMF) and its role in investigating science classroom discourse, it became increasingly clear that understanding the central concept of 'meaning-meaning' required greater theoretical engagement. I discovered this engagement in Derry's philosophical re-interpretation of Vygotsky that discussed a reorientation of 'meaning-making'. As an epistemological theory, the application of inferentialism in education remains very much in its infancy. Therefore, in the present thesis, I placed a heavy emphasis on illustrating the potential applied aspects of this theoretical perspective. Subsequently, the teaching illustrations and teacher resources I have discussed remain limited to theoretical contributions. They are yet to be trialed and tested with teachers in classroom practice, thus requiring a thorough, empirical follow-up study.

I drew relations with more traditional representational approaches to provide greater theoretical clarity of inferentialism, taking Mortimer and Scott's analytic framework as a paradigmatic example. Since inferentialism introduces notoriously complex vocabulary, I limited my examples primarily to the classification of materials and, for variation, also drew on classification examples from the topic 'Earth and Space'. The topic of materials is addressed in Year 5 as 'Properties and their changes', which extends beyond classification to address many other issues and concepts such as mixtures, solutions and reversible and irreversible changes. However, these discussions have been set aside to foreground the philosophical argument and theoretical reorientation involved in thinking about the nature of meaning-making in classroom thought and talk. An in-depth discussion of the topic of materials would require a complete treatment on its own. Such issues could be developed within primary science by including cross-curricular subjects in which inferentialism has been developed, such as Mathematics (Bakker, Ben-Zvi, Makar, 2017), Geography (Firth, 2017) and History (McCrory, 2015; 2017). The science topic ‘materials’, cross-curricular relations and the role of classification in science education and primary education, more specifically, would be rich areas for future discussion and research.

11.1 Reconfiguring Meaning-Making

I selected primary science topics, Earth and Space and Materials, to show how inferentialism plays out in the classroom and orientates our thinking about knowledge, learning, meaning and classroom talk.

By the time children are in Year 5, they already have their own ideas about the sun, moon, night and day, and the seasons. In this manner, the topic of Earth and Space and related science concepts already function as part of a readily accessible and holistic context. The concepts to be introduced, discussed and explained already function as part of an entire network of other ideas (an inferential space of reasons). This holistic context using Earth and Space offered a helpful contrast in discussing the topic of Materials and classification. With the former topic, I illustrated how inferentialism exposes how concepts are linked systematically in thinking and talking about Earth and Space concepts, such as ‘night and day’ or ‘planets’ and ‘moons’. In this topic, I illustrated how navigating the topic in teaching and talking science with children requires more than scientific names, vocabulary or definitions. An inferential perspective alerts teachers to the presuppositions in using a term within a knowledge domain or topic. I took ‘planet' as an example. The teacher initially assumed a planet to be ‘anything that goes round the Sun’. However, through discussions and unpacking these concepts, the teacher and I developed a systematic and coherent account of planets that gave reasons why Earth is a planet and Pluto is not. These reasons extend to support an understanding of other related concepts. For example, spherical planets relate to axis, rotation and curvature concepts. This awareness of the interrelation between concepts provided a way to navigate the topic, which informed the teaching sequence (inferential orientation). Through challenging our assumptions and modifying our presuppositions, the teacher gained a first-person awareness of commitments and entitlements and the appropriate and inappropriate ways to use concepts in relation to the topic. She not only masters the use of concepts and reasons, unpinning their use, but as she navigates the topic from within her network of reasons, she becomes more responsive to her pupils' claims, their use of concepts and correctness within the scientific topic (normative space of reasons).

While Earth and Space illustrate an accessible topic, there did not seem to be a readily discernable holistic context regarding the topic materials. Classification, for example, can be approached in various ways (see Chapter Five), which requires selecting by the teacher, including activities and selecting objects and materials. Likewise, primary science resources may identify materials and offer activities and approaches which may involve a holistic context. The responsibility of navigating this topic, however, falls to the teacher.

The classification of materials in solids, liquids and gases provided an opportunity to illustrate how inferentialism practically foregrounds our responsibility in what we say and do. My initial step involved introducing a range of cards with statements as card-sort activity into classification. This modification demonstrated how differences constantly manifest in our conceptual activity in understanding the concepts of solids, liquids, and gases, even though they may not differ in the act of classifying materials. Although pupils may place an object in the same classification, it entails various presuppositions and related concepts. These relations in undertaking the task constitute the pupil's reasoning articulated in what they say and do, for example, classifying sand as a solid. A critical insight from an inferentialist perspective regarding the nature of concepts and meaning in classification is that understanding concepts is not to be located solely in doing the practical activity correctly, nor by saying or uttering the correct things under the appropriate circumstances (social contexts). According to an inferential view, every claim and act is linked to a constellation of other ideas. The practical act of classifying expresses our implicit inferential reasoning**.** However, it is not the pupils' reasoning that determines the meaning of science concepts. The relations between concepts in the scientific knowledge domain are a systematic network of compatible and incompatible claims which constitute the norms of scientific thought and talk in using concepts. These normative relations govern science discourse and practical reasoning in the science classroom. A critical inferentialist insight was acknowledging how teachers not only need to induct learners into scientific vocabulary or language-use but bring them into this holistic network of claims (a space of reasons). I introduced this idea in detail in Chapter Five as inferential semantics and as an account of meaning in terms of the norms governing the appropriate use of concepts in practical reasoning and discursive practices. I developed this further in Chapter Ten, where I offered resources to support teachers in becoming responsive to the norms governing activities and reasons underpinning classification and, subsequently, children's reasoning articulated in thought and talk of classroom discourse.

The modified activity and practical resources illustrate how classification serves as rules that constitute the norms of practical activity, reasoning and discourse, that is, the normative dimensions of knowledge and concepts. These rules constrain the moves made in classification and science discourse. Classification is not confined to a practical activity but is viewed as a reasoning or inferential activity. An activity in which one articulates one's reasons in using a concept in a particular way. The card resource opened pupils' implicit inferential reasoning to teacher assessment by making their reasoning more explicit. The card statements not only introduced claims or another activity. From an inferentialist perspective, these resources not only made pupils' reasoning activities available for teacher assessment in classroom talk. It also allowed the teacher to bring pupils into the knowledge domain by making pupils aware of the implicit rules that govern the permissible and impermissible ways to use concepts in science classrooms.

11.2 An Inferentialist Reorientation: An Overview

In this thesis, I have illustrated how an inferentialist perspective reconfigures an understanding of the meaning-making concept. I draw on Derry's analogy in referring to this philosophical reorientation as a 'turn of the kaleidoscope' (2013b). The central idea here is that familiar concepts, such as language, concepts, mind, meaning and communication, and by implication, learning and teaching, when viewed through an alternative epistemological lens, are reconfigured. These familiar concepts are reoriented and interpreted in new and innovative ways. This initial turn of the kaleidoscope sets up two contrasting views or modes of teaching and learning science. There are two different perspectives and vocabularies to describe science concepts and meaning in classroom talk. The MMF has been referred to as a representational approach to concepts, communication and their analysis and adopting a representational mode to teaching focusing on representing the science teaching. The inferential mode in teaching and learning emphasises the reasoning articulated in practice in being responsive and responsible in using concepts appropriate to the norms of the knowledge domain. I briefly summarise the inferentialist perspective from concept-meaning through to meaningful communication within a disciplinary knowledge domain.

Concepts

In explaining Brandom's inferentialism, I discussed how he views our discursive practice not from the perspective of linguistics or cognition but us as concepts-using beings ever-engaged in giving and asking for reasons. An inferentialist account of concept meaning was rendered not in terms of what something is but concerning our capacity for reasoning and making rational judgments, in giving and asking for reasons, that is what it is that we *do* in our social and discursive practices, thinking and talking that counts as conceptual content (meaning). Mortimer and Scott, following Wertsch, viewed concept-meaning in linguistic terms located in the pragmatics of language, i.e., the use of language given specific social contexts. Inferentialism focuses on our reasoning and concept meaning as ways of reasoning or using concepts constrained by the norms of the knowledge domain or discourse. Concept meaning is the (inferential) role a concept plays in reasoning in norm-governed practices. The rules determine the correctness of concept application in the thought and talk of the science classroom. Brandom's inferentialism puts a normative twist on semantic and pragmatic issues by foregrounding our rationality and autonomy, our capacity for reasoning, and freely making judgments and inferences in thought and talk while being constrained by norms in thought and talk with others. The meaning of concepts was no longer solely a linguistic nor social affair but a normative affair, not located in what we say or the circumstances of our utterances but in our reasoning articulated in discourse constrained by the norms of discourse, in the present case, science.

Communication and Analysis of Discourse:

Mortimer and Scott's framework focused on language use and linguistic pragmatics and took utterances as their unit of analysis in analysing discourse (see Chapters Three and Seven). Subsequently, their meaning-making analysis of classroom talk sought to make linguistic and communicative patterns visible. They represented the changes in the use and forms of utterances across a teaching sequence (communicative approaches, see Chapters Two and Three). In contrast, inferentialism focuses on concept-users as rational agents, taking their judgments as the unit of analysis in reasoning in discursive practice, viewed as giving and asking for reasons in the claims we make, norm-governed practices (normative pragmatics). Instead of focusing on representing linguistic moves, the analysis attends to moves as always made by interlocutors and their claims, not as some free-floating abstract move in discourse but always treated as a move by some player and of which each and every participant keeps track by making their own move. This was captured by Brandom's scorekeeping account of discourse (see Chapters Six and Seven). The key here is that the practice is viewed not only as social but perspectival, relative to each player, and the dynamics, as commitments, and entitlements are constantly being updated with every move. However, given the perspectival and dynamic nature of such practices, they are always subject to norms of discourse. It is a normative practice. The moves are not only isolated speech acts or utterances but related to other claims that precede them and that follow from them (inferential relations). These relations are normative relations determined by the norms of discourse or the knowledge domain, the rules of the game.

Implications for Teaching:

The meaning-making framework (MMF) provides teachers with a tool to represent communicative and discursive patterns that manifest in teaching their science lessons. The framework endows teachers with insight into planning and teaching sequences, where learners are inducted into a social language of science. The expert teacher or dialogic teacher engages learners through classroom talk and strikes a balance between dialogic and authoritative forms of talk or classroom discourse.

In contrast, though not necessarily in opposition, inferentialist insights focus on teachers and learners as engaged in autonomous reasoning and making judgments, in thinking and talking in science classrooms. Teaching and talking science are inducting them into a new language. More importantly, inferentialism views the teacher as initiating learners into a different set of norms in using concepts in thought and talk of the science classroom. They do not simply acquire a new language or participate in a school science community. The teacher in an inferential mode not only moves or balances different discourses but does so responsive to reasons articulated by learners in their concept use. The inferentially-oriented teacher aims not to strike a balance or manifest a rhythm but rather to calibrate pupils' concept use by engaging and challenging their reasoning, which manifests dialogic teaching patterns. The classroom talk is an ongoing teacher assessment of the *correctnesses* of applying concepts in the science classroom. It is not enough for learners to say or do the right thing under the appropriate circumstances, e.g., rehearsing the social language of science. In an inferential mode, the teacher aims to make learners aware of their responsibility for the concept they use and the claims they make. The subsequent classroom talk with extended exchange (i.e., IRF chains) is a natural corollary.

In this way, the teacher, through classroom talk, can challenge pupils' thought and talk, allowing her to calibrate their concept use and develop their responsiveness to the norms of concept application. The teacher and classroom talk makes explicit for them the correctnesses and incorrectnesses of what they think, say and do in the science classroom by using concepts in norm-governed ways as responsible participants in science classroom discourse. In this way, the inferential mode does not only attend to teaching rhythms and striking a balance. It instead makes explicit the teacher's judgments in planning and teaching, responsive to pupils' thought and talk in classroom activities that constitute teacher practices that manifest in particular and distinctive ways of expert teachers. I have tabulated the inferentialist reorientation of meaning-making reported above (see Table 27. below).

Inferential Reorientation of the Meaning-making Framework

	Dimensions	**Meaning-making Framework**	**Inferential Framework**
Theoretical	Philosophical Orientation	Representationalism	Inferentialism
	Vygotsky's Theory of Learning (*Chapter 4)*	Wertsch's Interpretation of Vygotsky's Mind and Meaning as Sociocultural Psychology	Derry's Interpretation of Mind and Meaning as (neo-) Hegelian Rationality
Analytical	Concepts (Semantics) (*Chapter 5)*	**A representationalist perspective** that views concept meaning (semantics) in linguistic terms	**An inferentialist perspective** that views concept meaning as an inferential role in norm-governed practices
	Communication (*Chapter 6)*	**Linguistic Practice** Language-use and utterances as unit of analysis	**Normative Pragmatism** Concept-use and judgments as the unit of analysis
	Analytic Insight (*Chapter 7)*	**Communicative Patterns:** A analytic approach that makes visible patterns in communicative approaches used to sequence teaching content and classroom talk	**Inferential Relations:** Teacher's awareness of a holistic system that relates concepts in approach planning for a topic and lessons.
Practical	Pedagogic Approach (*Chapter 8)*	**Representational Mode:** Dialogic Teaching approach to learning science as induction into the social language of science	**Inferential Mode:** Teaching science as an induction into a norm-governed space of reasons. Teaching and learning science as mastering concept-use in norm-govern practices, by becoming responsive and responsible for reasons articulated in thought and talk of the science classroom.
	Teacher Development (*Chapter 9)*	**Reflective and Planning Tool:** Teaching Rhythm: Representation of communicative/discourse patterns in teaching sequences	**Resources for Normative Authority:** Developing responsibility and responsiveness to reasons in concept use.
	Pedagogic Insight (*Chapter 10)*	**Striking a balance** in classroom talk, by using both dialogic and authoritative approaches.	**Calibrating concepts as** constituting classroom talk, that is teacher's responsiveness to reasons, which makes explicit the judgments that manifest as teaching rhythms and striking a balance.

Table 27. A Comparison of two epistemological frameworks

This thesis has sought to introduce incrementally the inferentialist view that considers the perspectival, dynamic and holistic nature of concepts, meaning and communication by foregrounding our mindedness in our social interactions and practices. In explaining our conceptual content (meaning) and concept usage (discursive practices), inferentialism takes as fundamental our rational autonomy in reasoning and making inferential judgments and our rational agency as underpinning our participation in norm-governed social and discursive practice. This inferential account offers a metaphor that views conceptual and discursive, not as two aspects that require relating (e.g., acquisition and participation) but as always already related and inseparable. In this sense, the mastering metaphor discussed in Chapter Eight offers a holistic, systematic and functional account of our thought and talk. The alternative inferential reorientation and subsequent vocabulary running from theory to practice makes the inferential mode visible or explicit in teaching and learning various activities in primary science. In sum, the inferentialist reorientation of meaning-making covers three areas, theoretical orientation, analytic approach and pedagogic implications. While I have focused mainly on my classroom examples and illustrations, the next section will review the implications for primary teachers in science classrooms.

11.3 Implications for Primary Science Classrooms

Here, I consider the practical implications of this reorientation of meaning-making for primary teachers in their classroom practices. Having presented an overview of how the inferentialist approach to meaning-making contrasts with the post-Vygotskian approach of MMF, I summarise the inferentialist insights below as three fundamental interconnected principles. These principles, as different facets of inferentialism, offer a holistic and unified reinterpretation of our understanding of science concepts and the role they play, from planning science lessons to classroom thought and talk:

i. ***Inferential Space of Reasons:*** This principle acknowledges the network of logical and normative relations teachers should be alerted to. They serve as the rules of concept use constituting the knowledge domain. In developing an awareness of these inferential relations as rules or norms, teachers also develop an inferential orientation to the knowledge domain. This orientation should inform their approach to planning, teaching and talking in science classrooms.

ii. ***Normative Authority:*** This principle relates to the teacher's judgments in making moves or inferences and navigating this normative space. This authority constitutes a player's concept mastery, that is, the correct application of concepts, with awareness of inferential commitments, entitlements and incompatibilities relations that constitute the rules and govern moves in thought, talk and action in science classrooms.

iii. ***Responsiveness to Reasons:*** This principle addresses the teacher's approach in classroom talk. It is not only her awareness of the norms of discourse but also her ability to assess the correctness and incorrectness of pupils' claims as reasons and inferences in classroom talk. As she checks, challenges, and calibrates their use of concepts or inferential reasoning, she is responsive to their reasons articulated in classroom talk.

I review each of these inferentialist principles below, relating them to the present thesis and illustrative examples.

11.3.1 An Inferential Space of Reasons: Planning and Teaching within Reason

The first inferentialist principle – an inferential space of reasons- involves alerting teachers to the nature of science concepts, their inferential role in thought and talk of a knowledge domain. Scientific knowledge is not a body of atomic, third-personal facts or free-floating statements situated 'between the ears' (Brandom, 2011), nor is it located within linguistic practices determined by social contexts. Instead, an inferential view considers science concepts within a knowledge domain as a coherent, logical network of claims - a space of reasons. This logical space and systematic relations constitute the norms that govern the correctnesses of applying science concepts in classroom thought and talk.

This inferential space of reasons constitutes the rules and moves in playing the game of giving and asking for reasons. For example, the concept of the 'planet' involves more than simply an object that orbits the Sun (see Chapter Nine). Brandom agrees with the linguistic pragmatist view, in that he acknowledges: 'that grasping a concept is mastering the *use* of a word.' (Brandom, 2001, p. 6 [*emphasis added*]). However, his inferential semantics explains concept meaning in terms of its functional role in reasoning with norm-governed discursive practices. This functional role is inferential and logically related to an entire network of other concepts as part of a systematic whole; as Brandom states, 'an inferential demarcation of the conceptual [is] that in order to master *any* concepts, one must master *many* concepts. For grasp of one concept consists in the mastery of at least some of its inferential relations to other concepts.' (2001, p. 49). A concept is a rule of inference logically related to other premises, conclusions, and preclusions in specific, systematic, and norm-governed ways. Responsiveness to this logical space of reasons endows the teacher with a certain degree of freedom in navigating the knowledge domain in making and assessing claims.

Moreover, this responsiveness to the inferential consequences and normative implications in applying concepts offer certain freedom in planning and teaching science. The teacher's focus in planning and teaching should not be solely on acquiring scientific vocabulary, the social context of language use, or participation in social language. Instead, inferentialism focuses on grasping concepts as reasons that justify claims in a systematic way. This systematicity consists of compatibility and incompatibility relations, which entail certain inferences while precluding others (inferential relations) and constitute appropriate ways of thinking and talking within the knowledge domain.

In Chapter Nine, I discussed the science topic of Earth and Space. Drawing on discussions with a primary teacher and classroom scenarios, I illustrated how the teacher’s beliefs or commitments influenced her thinking, both in lesson planning and classroom talk. Through our discussions, we engaged in the *game of giving and asking for reasons* for ourselves. It offered an opportunity to use concepts and revise our thinking, understanding and talk. In this way, it alerts the teacher to the inferential nature of concepts. Concepts could be understood not as words with meanings but as their inferential role in thought and talk. Concepts could be reinterpreted regarding their role in thought and talk as part of a systematic whole, an inferential space of reasons. In becoming a legitimate and better player, gaining entitlements and discerning what is a better reason for what, the discourse as a normative space of consequences became more explicit. The teacher oriented to this space of reasons offers greater freedom to navigate the topic and break away from a linear sequence or narrative script. An inferentially-oriented approach to planning allows the teacher to go ‘off script’ and adapt the lesson and sequence led by the teacher’s judgments and responsiveness to reasons her pupils articulate as opposed to a linear narrative or script that informs her teaching performance.

11.3.2 Normative Authority: An Inferential Mode in Teaching Science

In the final two primary science illustrations, I argued that teachers need not only an inferential orientation to the knowledge domain but also an inferential mode in planning and teaching. In planning a teaching sequence, teachers require more than an inferential awareness of this space of reasons; they should be able to navigate it. Thus, in recognising the teacher’s judgment in navigating this space, the second inferential principle addresses her awareness and normative authority in planning, teaching and talking. This authority derives from teachers’ practical mastery of the norm-governed application of concepts in drawing inferences and making assertions in navigating the logical space of reasons. The teacher's responsibility and authority are derived from discerning relevant, specific and appropriate reasons in justifying claims instead of repeating those made by other authoritative figures, such as scientists.

In discussing Earth and Space and Materials topics, the examples aimed at illustrating ways in which learning and teaching science involve more than naming, labelling, classifying or coming to grasp scientific vocabulary and its use in science classroom discourse of these activities. Such approaches would fall into representational modes in teaching. In contrast, in an inferential mode, the teacher privileges the reasons, focusing on what concepts do in reasoning in norm-governed practices instead of uttering the correct technical words or their use in appropriate classroom contexts. For example, classifying material as ‘solid’, ‘liquid’, or ‘gas’

(SLG) is not simply knowing where to place them or a list of attributes. An inferential approach requires appreciating the inferential role these classifications (SLG) as concepts play in thought and talk about materials. The teacher's judgment in classifying materials not only relates these concepts to describing felt properties (e.g., stiff, stretchy, wet) but also their role within scientific discourse in more systematic and persuasive ways, such as being supported by empirical measures of specific functional properties (e.g., hardness, viscosity).

In Earth and Space, the term 'planet' was not simply a matter of current scientific definitions. Discussing Earth and its shape, the inferential role of the concept 'planet' relates to a different set of judgments in contrast to discussions about Neptune or Pluto and their orbits (see Chapter Eight, even though they occupy the same space of reasons. The teacher, wielding specific practical know-how, endows her with an ability to move from a limited space of claims (right or wrong classifications) toward greater freedom in navigating a broader space of reasons and consequences (inferential reasoning).

The proposed (inferential) resources aimed to protect teachers from slipping into teaching that relies on naming, referring or classifying, i.e., representationalist modes. The resource sought to develop a normative authority by addressing the fragility of their knowledge by challenging them to justify their reasoning. In this manner, the resource could move them towards developing semantic responsibility for the concepts, meaning and meaning-making in classroom thought and talk. Providing teachers with prescribed activities and answers or even 'background information', descriptions or explanations would not suffice. In classroom talk, regardless of planning, the teacher may not be prepared for what the children say. However, she can prepare for how to hold them accountable for claims and reasons relevant to the game by being responsive to the rules and moves and navigating a space of reasons. In this way, she not only plans for the lesson or the talk but also prepares for responding within an inferential space. However, this comes with her normativity authority in leading the classroom discourse and responding to her pupils' claims and commitments.

In proposing inferentially-oriented teacher resources, I underscored how certain resources tended to neglect teachers' own rational autonomy and inferential commitments. I found that teacher resources or development programmes often deferred understanding of scientific content to peer discussions, teacher reflection, or the authority of the scientific community. I identified this issue of neglect with representationalism. In this manner, there was no opportunity for the teacher to develop their awareness of the norm-governed relations that constitutes the conceptual content of scientific concepts, i.e., meaning. It reflected how the challenges of meaning-making and conceptual development extend beyond the classroom to teacher resources and professional development. Inferentialism reorients the role of authority concerning the teacher, from the authority of scientific knowledge to teachers' normative authority in making judgments responsive to the rules in playing the game of giving and asking for reasons and engaging children. This relates to the final principle that not only concerns the teacher's orientation to the knowledge domain but also her social interactions with pupils in classroom talk.

11.3.3 Responsiveness to Reasons: Responsive Teacher Talk

The third and final inferential principle concerns the teacher's responsiveness to reasons, which underpins her receptivity and responsivity to pupils' claims and inferences articulated in classroom talk. From an inferentialist perspective, classroom discussions aim to support children to become responsive to reasons justifying claims and the norms that govern the inter-relations between claims. The inferentially-oriented teacher, responding with normative authority in classroom talk, understands that the correctnesses of statements is not and should not be evaluated in a one-shot manner. In other words, one cannot take an utterance or a word as sufficient answer, for it does not give reasons that assertion articulates.

The inferentialist lesson presented by the scorekeeping analysis was that assessing children's conceptual understanding lies not only in what they say or utter. Through classroom talk, the teacher unpacks and explores what they mean. She challenges their claims and thinking in seeking justifications, all the while assessing for consistencies and incompatibilities in their reasoning articulated in what they say do and believe. Classroom talk, when understood as an inferential activity, as a game of giving and asking for reasons, is a potentially endless process. However, classroom talk remains constrained not only by the rules of the game but also by teacher judgment in classroom activities. As an expert player, the teacher assesses and responds to pupils' moves articulated in classroom talk and activities. The teacher responds by checking, challenging and endorsing pupils' reasons (ICE) and calibrates children's inferential reasoning and discursive commitments within the normative space of reasons, that is, their discursive reasoning.

In developing inferentially-oriented teacher resources, I aimed to illustrate how the semantic responsibility of the teacher constitutes her normative authority in using concepts. In other words, understanding science concepts was not only an ability to participate in science discursive practices. The teacher's authority, the responsibility she bears and the authority she wields is derived from her inferential orientation to the knowledge domain in justifying claims rather than deferring to other authoritative figures. For example, not just knowing Pluto was demoted to a dwarf planet. The teacher should be aware of the facts but also the reasons that justify the fact or claim. These requirements may, of course, be viewed as being too high in considering non-specialist primary teachers. However, my claim regarding inferentialism is not that teachers are privy to every reason for making claims and inferences. Rather, the classification resources I developed for teachers sought to endow teachers with relevant reasons within an interconnected system. Furthermore, the resources sought to develop an inferential orientation to this normative space of reasons. Herein lies the teacher's normative authority, albeit limited to the science topic to be taught and discussed.

In this manner, these inferential principles together address a whole other dimension within classroom thought and talk or meaning-making. By offering an alternative epistemological perspective, inferentialism responds to the theory-practice gap encountered by dialogic researchers (see Chapters Three and Seven). Rather than address the problem of the gap, inferentialism dissolves the problem by addressing implicit representational commitments. Bringing the teacher's own judgments into the picture and her responsiveness to pupil claims as also judgments in their own right and tracking and tracing each other's presuppositions (scorekeeping) in classroom talk reveals the perspectival nature of concept meaning and dynamic nature of discursive practices. Inferentialism gives primacy to our rationality and reasoning in our distinctive norm-governed practices; they are fundamental and primitive. Any relation, whether a theory-practice gap, acquisition-participation tension, or word-world reference relations, is not considered some third-person entity or process that needs explaining. From an inferentialist perspective, representing such relations by naming, labelling or classifying them does not explain them. Explaining such relations requires attending to the specific work of humans, that is, giving and asking for reasons in norm-governed ways.

The point is that, like learning to play chess, there are pieces, boards, moves and scores. However, none of these items or tools provides a conceptual understanding of playing the game, i.e., a player's responsiveness to moves and response in changing the score. Developing this responsiveness involves a practice-based approach. It requires playing the game and becoming responsive to scoring moves. In learning to play well, pupils develop an ability to make appropriate moves and respond to moves and discern which moves are better. A pupil's capacity to articulate systematic reasons for their thought and talk is the extent of their conceptual understanding. Their understanding cannot be detected through their use of scientific language or participation. It requires holding pupils to account in discursive practice. In this manner, the teacher can expose their semantic responsibility expressed through the use of scientific concepts in science classrooms. Classroom talk is the articulation of their inferential reasoning, their constellation of inferential commitments that constitute their conceptual understanding. The expert teacher is responsive to their talk as reasons, as a constellation of discursive commitments in playing the game. In playing the game with pupils, the teacher seeks to weed out incompatibilities and endorse compatibilities in their inferential commitments, inducting them into the game as legitimate players and developing responsiveness to the norms and reasons for getting better at playing the game of giving and asking for reasons.

The implication thus lies in acknowledging how in teaching and teacher development, representations or analytic tools for teacher reflection (e.g., communicative approach or discourse analysis) that focus on surface features remains insufficient in providing insights into how thought and talk for human understanding is achieved. In contrast, once an inferentialist approach to thought and talk is understood as the ‘sort of social-perspectival, dialogical inferential articulation that makes possible the objectivity of conceptual content’ (Brandom, 2001, p. 37), it privileges the role norms and reasons play in explaining our discursive practices. These norms and reasons are always dynamic, involving players that move with and for reasons. These moves can only be understood in relation and relative to some player perspectives. This dynamic and perspectival nature of our discursive practice is why the development of teacher practices and subsequent resources requires a practice-based approach, that is engaging reasons. It is only when teachers are faced with taking responsibility for what they do and say and being responsive to reasons and norms in justifying their move in a discursive way that they can develop receptivity, sensitivity and responsiveness to reasons in initiating learners into the space of reasons, not through forms of talk but through giving and asking for reasons, in calibrating the concept usage in becoming responsible for the role concepts play in their thought and talk in science classroom dialogue.

11.4 Limitations of Study and Future Research

11.4.1 Inferentialism and Primary Science

This thesis has been inspired and informed by Derry’s inferentialist interpretation of Vygotsky (Derry, 2013a). While my illustrations and critique have focused on Mortimer and Scott’s Meaning-making Framework (MMF), the theoretical implications continue further afield. There are several key ideas which I have limited in discussion but would like to pursue and develop in future research. In discussing and developing the idea of the *space of reasons,* there are fruitful relations that relate to Vygotsky's *zone of proximal development*. As this is a central Vygotskian concept familiar to primary educators, it provides a valuable lens through which to explore conceptual change research (Scott, Asoko and Leach, 2007) and relate this to Mortimer and Scott's response to conceptual change, namely *conceptual profiles* (Mortimer, 1995; 2000; Mortimer and El Hani, 2014). My focus on MMF and limited space meant I had to forgo a detailed discussion of Mortimer's *conceptual profiles.* What is of particular interest is that to grapple with the tension between acquisition and participation metaphor (see Chapter Eight), Mortimer enlisted the support of philosopher Charbel El Hani[102] (El Hani and Mortimer, 2007; Mortimer, Scott and El Hani, 2011; Mortimer and El Hani, 2014). This collaboration focused on developing theoretical and methodological perspectives appealing to American Pragmatism. However, their discussion stops short of American Pragmatists from the Pittsburgh School of Philosophy (see Chapter Four, §4.1). Further discussion in light of Brandom's normative pragmatism I feel would make a significant contribution.

Other related areas include Wertsch's communicative theory, as influenced by Jürgen Habermas, who also addressed normativity. Given that Brandom has debated with Habermas, this would be a fruitful area to explore in relation to communicative theory, analysis and dialogic teaching.

Finally, I focused on selected examples of classification. This common approach is adopted in primary science and primary education more broadly. Discussing the role of classification could be extended to Piaget, Vygotsky and concept development. While Derry has written on Piaget and Kant, her former

[102] Phil Scott sadly passed in July 2011. Mortimer and colleagues continued to work on and develop their ideas.

student Sheila Webb (2020; 2022) has provided a recent reinterpretation of Kant in view of the Pittsburgh school of philosophy (Maher, 2012). This would provide a discussion not only of classification in classroom teaching but as related to the curriculum.

11.4.2 Inferential Resources for Primary Science Teachers

The practical resources I developed served as an illustrative device and, thus for all practical intent and purposes, remain limited. My entry point into educational research lies in Educational Technology and the development of Virtual Labs in Science, Technology, Engineering and Mathematics (STEM) subjects (Achuthan, Sreelatha, Surendran et al., 2011). Drawing on this background, I propose that these resources could be developed through more adaptive designs and digital formats with teachers in professional development. This work can be developed along several empirical dimensions relating to classroom activities and professional teacher development. A fruitful area currently under development involves STEM workshops, working collaboratively with primary science teachers and science hub coordinators to further develop and adapt resources related to classroom practice[103]. The card statements (§5.4 and Appendix 2 and 3), developed as a digital resource, could be extended to include a bank of card statements spanning a broad spectrum of materials from clear-cut to more advanced and cutting-edge materials. These digital resources could form part of a social platform or community hub as collaborative resources for teachers. Digital inferential resource may allow teachers to play the game of giving and asking for reasons, which in turn may inspire the

[103] A special tribute is due to Ms Kapoor, who has been so generous with her time in assisting in my research of primary classrooms. She has not only been an inspiration, but her sustained enthusiasm continues to develop inferentialist research and future research projects.

development of other practice-based teacher development resources. Although the proposed inferentially-oriented classification resources were developed for both classroom teaching and teacher development (see §5.3 and §9.3, respectively), they offer a contrast to common representational resources. As such, it opens up possible avenues for exploring inferentialism and dialogic approaches in future research.

11.4.3 Inferentialism and Communication in Healthcare Education

In considering concrete applications of inferentialism, some research opportunities have emerged extending beyond the classroom. The theoretical work developed along inferentialist lines also provides a basis for empirical research being developed in the area of healthcare and clinical communication. There are currently several research studies in development that focus on practitioner-patient communication and dialogue concerning diet, nutrition and health literacy (Johansson, Surendran, Croker, Dronsfield, Goff, Hutchinson, and Belsi, 2023[104] and many forthcoming[105]). Although primary science and clinical communication may seem worlds apart, the connecting thread of science concepts, health literacy, meaning-making, and communication make the inferentialist lens presented in this thesis both relevant and of significant value. The challenge in these clinical interactions is related to science communication and meaning-making. Therefore, an inferential orientation offers fruitful avenues and fertile ground for future research[106]. This inferentialist line of thinking has recently emerged within the theoretical literature in healthcare research

[104] The Well-being and Lifestyle in Transplantation (WALT) project focuses on clinical communication, patient education, and health literacy. The project was presented at UK Kidney Association Conference 2022.
[105] Publications from this conference and other projects are forthcoming, which include several mixed methods studies involving older people. The abstract for the mixed method study was accepted for UK Kidney Week Conference 2023 and won Best Clinical Abstract. There is also a third project related to health inequalities for which papers are also forthcoming, including some methodological and theoretical papers.
[106] Interestingly, Derry's research in its early stages was also developed in the context of healthcare (see Daniels, James and Rahman et al., 2007).

(Kibble, 2014; Clarke and Russo, 2016; Francesca, Marcello, Grazia, and Pietro, 2016). As the project works toward developing a digital intervention, it also draws on Learning Sciences and a design-based research methodology. Design-based research thus opens up another avenue for applying inferentialism (Bakker, 2018; Bakker, Ben-Zvi and Makar, 2017). This broader context of educational research extends the application of inferentialism and Vygotskian theory beyond the classroom walls to cross-fertilise existing classroom research with science communication and STEM research in ways that open new directions and inspire future research studies. With this inferentialist re-orientation in approaching meaning-making research, I return to my initial entry point to educational research within educational technology, Learning Sciences, and human communication and future directions viewed through a new perspective.

. . both a new world,
and the old made explicit ...
We shall not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first time.
T. S. ELIOT, "Four Quartets" (cited in Brandom, 1994, *Making It Explicit*)

Epilogue

Following our collaboration, the teacher reported several episodes that reflected her own development as a teacher and science lead. For example, in planning Earth and Space, we had worked through thinking about the curvature of the Earth. In reviewing pedagogic resources, we discussed and worked through the historical accounts of discovering the Earth's shape, such as Eratosthenes and Aristotle (Skamp, 2015; Australian Academy of Science, 2014a). During a meeting with the head teacher, the teacher explained the lesson plan and discussed the teaching episode. The head teacher to her surprise was pressed to ask how she managed to grasp such ideas. She responded by referring to our discussions. Our work together has inspired Ms Kapoor to utilise our work in supporting her application for a primary science quality mark for the school, which she gained. In reviewing her own lessons, she began supporting other teachers at school to develop and discern their learning intentions of lessons, in more systematic ways that sought to expose rational continuities and logical inconsistencies. She went on to take up the role of local primary science hub coordinator.

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Appendices

Appendix 1: Researcher Identity

Academic Philosophy: A Call for Diversity

In over 20 years of academic studies in philosophy, I have never once encountered a teacher of colour. While, as a student of philosophy, I have either been the only person of colour or in the extreme minority. In this short autobiographical reflection, I discuss the impact this lack of diversity in academia has had on me and my experience of studying philosophy at academic institutions. Although I do not explicitly discuss these issues in my thesis, they, nevertheless, exercise an enduring influence on my personal and research identities, which I attempt to articulate in the following statement.

1. A Personal Context in Studying Philosophy

I was born and raised in East London. My parents were both working class and of South-Indian heritage. I was fortunate to be initiated into Eastern philosophy at a young age, which is atypical within the south-Indian community. By Eastern philosophy, I refer specifically to Advaita Vedanta, a branch of Indian philosophy. I think it suffices to acknowledge here and avoid philosophical details, that 'Advaita' is a Sanskrit term meaning 'not-two' or 'non-dual' and 'Vedanta' is one of twelve major systems of Indian philosophy. As a result, I have always benefitted and suffered from having the two voices of East and West, constantly at loggerheads inside and outside of the school classroom. Entering higher education studies, I enrolled on an undergraduate degree in Aerospace engineering. However, I dropped out having already become disenchanted with Science at A-level. In search of meaningful answers that could satisfy my intellectual concerns regarding the nature of the world, mind, and life, I turned to Eastern philosophy and headed to India. Now, I am aware this may conjure up images of, some lone Buddha, sitting in meditation under a tree, divorced from the world. To this day, I remain fearful of such attributions; of being branded religious, unscientific or even unacademic. It would be years later before I find validation of my intuitions expressed by the Pittsburgh School of Philosophy, a group of neo-Hegelian thinkers rooted in German idealist tradition. This school of thought has been a major influence on my doctoral research and present thesis. Thus, my aim here is two-fold, on the one hand, to demystify and dispel, at least some preconceptions and stereotypes of Eastern philosophies, while on the other to illuminate some inherent parallels and lines of connections. I am not alone in this, as such concerns have been shared by Anglo-American scholars from various disciplines, such as Richard Nisbett, Aldous Huxley, Fritjof Capra and Jay Garfield.

As I journeyed Eastwards, I enrolled at a 'Gurukula' (an indigenous system of education in India) before its decimation at the hands of European invaders and colonisation. This Gurukula, was in the literal sense, a school of philosophy for Advaita Vedanta (non-dualist branch of Indian Idealism), located in Kerala, South India. Inspired by contemporary Indian philosopher Shree Narayana Guru (c.1854-1928), this scholastic centre engaged in the study of Indian forms of metaphysics, logic, epistemology and more. Focusing on indigenous philosophical texts, the Upanishads, and Bhagavad Gita to name but a few, our scholastic discussions and debates also drew on world philosophies, religions and scientific worldviews, within an integrated holistic framework. A couple of western philosophers served to re-interpret Western Philosophy in line with a non-dualist orientation, namely Hegel and

Spinoza. Both Eastern and Western philosophers were subjected to intense contemplative study. A year later, I returned to the UK to complete my undergraduate degree in Western philosophy in the Analytic tradition. I gained admission to Heythrop College, a specialist in philosophy and theology but also a Jesuit college. Looking back, it seems strange that as a student of Indian heritage, I would study Western philosophy at a Jesuit institute and simultaneously Advaita Vedanta at an Indian Gurukula. Although this may all seem completely unrelated to my research study, to better grasp the relations, I turn briefly to outline the philosophical context of my thesis.

2. Western Philosophy and My Research

Central to my doctoral thesis is Jan Derry's philosophical re-assessment of Anglo-American Vygotsky scholarship. She not only spotlights the significant role philosophers Spinoza and Hegel played in Vygotsky's own thinking but also relates his work to contemporary developments in philosophy and in particular neo-Hegelian philosopher Robert Brandom. Brandom has been widely acknowledged as one of the foremost philosophical thinkers of our times. His systematic philosophy of inferentialism adopts a non-dualist epistemology and contributes to the revival of German Idealism within the analytic tradition. The reception of Derry's Vygotsky scholarship and Brandom's philosophy was a pivotal moment in my research inquiry. Inferentialism offered a philosophical orientation, which immediately resonated with my intuitions and research work. It opened up a new space within a Western philosophy where my Eastern perspective could sit comfortably without immediately being pigeon-holed into religion – a place I could call home. I gained an immense sense of relief and liberation, which had a profound effect on me. I had finally found an academic outlet for my self-expression that aligned with my philosophical worldview: an epistemological perspective that I could adopt without fear of being judged as religious or unacademic.

A key takeaway message from Derry's work but also other Vygotsky studies scholars (Bakhurst, 2011; Dafermos 2018a) was a crucial and deliberate attempt to acknowledge certain cultural and philosophical responsiveness. Their focus lies in reorienting Russian thinkers and philosophy from Anglo-American interpretations. If philosophy as a discipline, and academia more broadly, remains insensitive to historical-cultural responsiveness, then the exclusion is a natural corollary. Philosopher Jay Garfield is of particular interest here, as he has not only made explicit links between Brandom's mentor Wilfred Sellars and Eastern philosophies but has gone further to call out academic philosophy on its lack of diversity in the New York Times, titled with his central proclamation that 'if philosophy, doesn't diversify we should just call it what it is'. For minority students like me, such calls begin to make visible, explicit and legitimise the sorts of experiences that form part of my everyday experience and expectation as a student of colour, which I have had to contend with and endure throughout my entire academic life. Thus, I turn to exemplify some of my experiences in studying academic philosophy and doctoral seminars at university.

3. Academic Philosophy as Cultural Constraints

I want to start with my very first encounter with philosophy. I vividly recall the first lesson and the proclamation made by the lecturer. He declared in a loud and affirmative voice, 'In analytic philosophy, we are not interested in historical or cultural contexts. We are interested in the logic of the argument'. My immediate thought was how can one possibly separate them. Of course, I was an undergraduate and kept my mouth firmly shut. During my academic life, whenever such contentious statements were raised, I learned to suppress my Indian philosophical thinking, for fear of being judged religious or lacking in academic rigour. The best advice I received in terms of my academic development was given by an astute tutor who in discussing my work and uncovering my interests in Eastern philosophy, told me 'When you're doing Western philosophy, just do Western philosophy'. In hindsight, I view such advice, as helpful as it was, as being misguided. Such a stark distinction enabled me to develop and move forward, at least in my academic study of analytic philosophy. In retrospect, however, I realise now it was a pivotal moment, where I was forced to sacrifice my own identity and self-expression. It was not until I discovered Derry's Vygotsky scholarship, which tethered Spinoza and Hegel together, that I was able to repair and reconnect to a severed sense of self, which I had lost almost 20 years ago. It was an emancipatory experience, as though I had been liberated from some inner emotional-mental-spiritual prison. However, because of the current revival of Hegel and German Idealism in the analytic tradition, I could finally take pride in my Indian philosophical heritage within academic settings. Rather than viewing it as flawed and in need of defending, I began to appreciate its strength. This was particularly the case when considering emerging theories of consciousness research and the growing validation and acceptance of meditation, yoga and Eastern philosophies in mainstream culture and academic research.

When I encountered the hard problem of consciousness during my MSc in History and Philosophy of Science, I had to relive my undergraduate experience. Again, in the very first lesson, the lecturer pronounced: 'Assumption zero in the philosophy of science, is that the world is mind-independent'. Again, I was utterly dumbfounded, left baffled by what seemed like a déjà vu moment. I thought we were doing philosophy of science not learning philosophy for scientists! I understood back then the role of belief systems as a worldview, that pervades all human thought, whether science, religion or philosophy. However, this did not seem to apply to ‘assumption 0’. Here again, Derry’s Vygotsky scholarship as related to knowledge, concepts and consciousness, offered a bridge between Western voices and my Eastern intuitions. It was sheer joy, when I discovered, that Wilfred Sellars, one of Brandom’s heroes, was himself a philosopher of science.

At the doctoral level, it is not uncommon for comments and remarks to be made that define the norms and boundaries of academic discourse. When raising ideas from Eastern or indigenous perspectives, whether they be Indian, African nations, or Native American, they are often met with a challenge, treated with derision, as incredulous, lacking relevance or as taking things too far. From my point of view, as a person of colour (and having studied philosophy across two different cultures), to be open-minded in thought and talk requires a certain commitment to engage with, and value a diversity of beliefs, ways of talking and being. It requires academic institutions, researchers and audiences, to step up, discuss and debate issues in ways that not only allow but encourage challenging Anglo-American-centric perspectives as opposed to taking them as universally applicable. In a global world, facing increasingly global issues now seems to be the time for educational research and academic institutions to recognise, appreciate and engage in diverse, inclusive global perspectives and dialogue. It involves taking aim at those very notions portrayed as underpinning academic philosophy. The idea that the philosophical enterprise can be undertaken in isolation from global historical and cultural considerations, or that a mind-independent world can be taken as an unquestioned assumption ‘0’. I was unaware that these academic constraints were being placed on me as a student, on my personal and research identity – my personhood.

4. Finding My Place in Academic Research

In this biographical sketch, I have taken the opportunity to express some of the cultural tensions and academic constraints I have personally experienced within academia, specifically within philosophy. I also sought to spotlight why I found Brandom's inferentialism and Derry's Vygotsky scholarship so inspiring and meaningful, extending beyond my thesis. However, given I have been greatly inspired by Kant, Hegel and Brandom, I am also aware there have been discussions on the expression of racist attitudes and comments related to their time (Bernasconi, 2003; McCarney, 2003). As I read Kant or Hegel, there is a need for the academic community to acknowledge that I am being forced to engage with those who have made remarks that belittle my heritage. I have had to consciously compartmentalise this issue, so that I can deal with the issue at hand, namely my thesis. There is however a smouldering cauldron of unexpressed emotions seething beneath the surface. Even with contemporary thinkers such as Brandom, as much as I admire his work, his use of the n-word in print (2001, p. 70) is a painful indictment of how Western philosophy fails people of colour and as a whole, remains a problematic enterprise. Conversely, the contribution of Eastern traditions to German philosophers has been largely ignored (Herling, 2014). Now, there has been a slow but emerging body of work in recognising such influences (Schönfeld and Thompson, 2003; Nisbett, 2005; Herling, 2014; Garfield, 2011, 2015, 2018). However, if academic establishments fail to engage and include discussions about the influence and impact of global and cross-cultural traditions and the role European colonialism has played and continues to play, then these institutions continually and uncritically endorse them. A Western worldview is inseparably intertwined with its colonial history. As such, it continues to exercise normative constraints on my expressive freedom to articulate my beliefs, knowledge and worldview. Again, this is not a line of argument I have articulated in my thesis. It is pertinent to state it nonetheless, as it deeply impinges on my identity, personally and professionally. The present appendix is thus an attempt to acknowledge that I do not wish to leave such a deep and problematic issue unsaid or untouched. Despite long-standing arguments that have rallied against Orientalism and Colonialism as a historical phenomenon, though they have garnered recognition in a range of academic subjects and education, present-day academic narratives, roles and implications remain largely ignored within philosophy and by implication philosophy of education, science and social sciences (Bhambra, Gebrial, and Nişancıoğlu, 2018; Eddo-Lodge, 2020; Miller, Towers, and Surendran, 2022, Miller, Surendran and Towers, 2023). If philosophy remains closed, refusing to diversify, or perhaps even incapable of it, it will continue to disenchant academia not only for people of colour and minority ethnic groups like myself but for future generations of learners and teachers.

With the above said, after years of academic studies, I am thrilled to have found a platform on which finally I gain a certain level of expressive freedom. This freedom lies in taking pride and feeling no shame in looking East but also recognising there is nothing new in doing so. Since Brandom opens his magus opus 'Making It Explicit' with T. S. Eliot, I want to close this reflection by sharing Eliot's thoughts on philosophy, as he had studied American, European and Eastern perspectives:

> A good half of the effort of understanding what the Indian philosophers were after–and their subtleties make most of the great European philosophers look like schoolboys – lay in trying to erase from my mind all the categories and

kinds of distinction common to European philosophy from the time of the Greeks… (Eliot, 1934, cited in Rao, 1963, p. 572).

Just as Eliot's house sits adjacent to UCL IOE, it seems a fit metaphor for how I found my own home within academia. I do not seek to pit East against West. It seems good sense to me, that if we wish philosophy to advance, we need to move beyond the notion of anachronistic ideals of an East-West divide. We need a truly global philosophy, that embraces an inclusive, diverse and collaborative approach to the philosophical enterprise. Philosophy should be understood as a collective human endeavour towards the constructive flourishing of our shared humanity.

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Appendix 2: Liquid Card Statements

Liquid Justification Cards: Water

1. Water does not have its own shape.	2. Water can flow.	3. Water can be physically handled.	4. Water has a fixed volume.
5. Water cannot be handled by hand.	6. Water is not a load-bearing material.	7. Water has its own shape.	8. Water is elastic or stretchy.
9. Water can be poured.	10. Water does not have surface texture.	11. Water does not flow.	12. Water doesn't break or breaks easily.
13. You can put your hand through water.	14. Water is not hard.	15. Water is hard.	16. Water is absorbent.
17. Water feels wet.	18. Water can be compressed.	19. Water feels rough.	20. Sand is practically incompressible.
21. Water has surface tension.	22. Water has low viscosity.	23. Water has a higher density than ice.	24. Water has mass.
25. Water has no hardness.	26. Water has no measurable rigidity.	27. Water has a boiling point of around 100c.	28. Water is a fluid.

Appendix 3: Gas Card Statements

Gas Justification Cards: Air

1. Air has a definite shape.	2. Air has no definite shape.	3. Air bends easily.	4. Air is flexible.
5. Air can be struck/hit.	6. Air has a fixed volume.	7. Air can be stirred.	8. Air is elastic.
9. Air cannot be poured.	10. Air can flow down a slope.	11. Air can flow.	12. Air does not break.
13. You cannot put hand through air.	14. Air does not pour.	15. You can put you hand through air.	16. Air is compressible.
17. Air feels smooth.	18. Air is stiff or rigid.	19. Air feels wet.	20. Air is incompressible.
21. Air no tensile strength.	22. Air has no viscosity.	23. Air has very low density.	24. Air has mass.
25. Air is a mixture.	26. Air is combustible.	27. Air has no rigidity.	28. Air is a fluid.

Appendix 4: Scorekeeping Analysis

Additional Scorekeeping Analysis Steps

(3) Teacher agrees with Jessica and endorses her claim

(T2): ***Mrs Simon:*** *Yeah! Pushes and pulls ... and forces, we, I'll just summarise what we did last week actually. Forces are needed to start things moving. Think about the things we did out in the yard. What else might they be used for?*

Mrs Simon makes *her* second move, a speech act labelled (T2), which constitutes the third move in the discursive game. Here, the teacher responds to Jessica's move (J1) that made explicit her belief or commitment to forces being a push or a pull (C2). Mrs Simon responds saying '*Yeah! Pushes and pulls ... and forces,'* offering a nod of approval to Jessica's belief, and subsequently *endorsing* her belief, thus granting her and the class permission or the authority to retain and repeat Jessica's assertion in other situations. In other words, the teacher acknowledges the correctness of Jessica's claim in accordance with the *rules* of the game. Thus, Mrs Simon's move (T2) and initial assertion *entitles* Jessica and the class to her assertional commitment (E2).

Mrs Simon goes on summarise the activities children participated in last week and what she assumes they learnt, or should have learnt, from her point of view. What they did last week was play games like baseball/cricket, hitting the ball with the bat (See, Chapter Six, §6.2), quite fitting with the scorekeeping analogy (See Chapter Six). Following through the teacher's initial question (*query* Q_1) and Jessica's assertion (C2), Mrs Simon offers another but related assertion claiming, '*Forces are needed to start things moving.*' (C3). The teacher makes her own inferentially related belief (committive inferential commitment) about forces explicit, by acknowledging it by way of assertion (*assertional commitment,* C3). The assertion by default entitles other players, her pupils to undertake the commitment and repeat the claim themselves (*assertional entitlement*, E3). However, being the teacher and more knowledgeable about the correct and incorrect ways to apply and articulate the concept in scientific ways, makes her responsive to compatible and incompatible related claims, or reasons that endows her with an authority, the children may yet to development in thinking and talking about the concept force.

In recollecting the last lesson, Mrs Simon may well acknowledge certain commitments for herself, but these have not been articulated in her assertion '*Think about the things we did out in the yard.'*. Thus, remains unacknowledged and unattributable by her pupils by this assertion. It is her query that serve to make explicit to what extent pupils have gained inferential commitment in relation to the concept force.

Mrs Simon ends her move with a question. She asks her class '*What else might they be used for?*', referring to forces and more specifically relating to the activities throwing and batting balls. This query serves as an *auxiliary move* that seeks make explicit other inferential commitments related to forces, which her pupils may or may not have undertaken. At this stage of the game, the teacher is not, as of yet, entitled to attribute her set of commitments and entitlements to her class or pupils. In concluding her move, she does not change the score. The query does not add anything in terms of the meaning of what has been said or thought in the game. The move 'asks for reasons' but does not itself alter the score of the game.

The question in invoking the term 'used', has the implication of suggesting instrumental or tool like role of force, that is it reifies the concept 'force'. I suggest that such classroom science talk reducing the term to empirical description, as opposed to developing scientific understanding, that awareness of the inferential relations or the concepts function in thinking and talking about the world or phenomena. It may seem like nit-picking or pedantic, but what I want to bring to the fore here is the inferential structure and normative sensitivity that manifest in queries articulated in ore loose as opposed to systematic ways. This point is more evident in Mrs Simon's queries raised in turns 12 and 15, where these descriptive queries return and the dialogue displaying characteristic of what has been referred to as 'guess what's in my head' approach. The argument I develop here, is not to take direct issue with the teacher, teaching or her interaction, but rather to draw attention to the benefits of view such practices through an inferential lens. For it acknowledges the absence and brings the systemacity of norm-governed inferential relations, that is the inferential structure and normative character of discursive practice, into a more prominent role. The teacher on an inferential mode seeks to extend or amplify children's thinking about what forces are how the function, what they do, such as push and pull, which can explain the starting and stopping of things moving (motion). The teacher view or mode is not only directed to assessing definition of forces, which Jessica's assertion fits and approved by the teacher. The teacher should also be invested in identifying, connecting and correcting related ideas, with awareness to compatible and in compatible relation, that is the appropriate and inappropriate use of concepts expressed through thought and talk. In other words, connecting and articulating ideas in line with accepted scientific ways of thinking or reasoning, which constitute the correct use or grasp of the concept 'force'.

In sum, the analysis shows that the teacher agrees Jessica claim that forces are 'a push or a pull' is in fact correct (C2), thus giving permission to Jessica and the class to make use of this idea in relation to forces (E2). Mrs Simon develops Jessica's claim, relating forces to the idea that the 'start things moving'(C3). In doing so gives all the pupils the right to use this idea in their thinking about forces, in what has been said and for use in the discussion going forward (E3). Finally, she ends with a question, that asks for other ideas about forces, that may be related to what has been said or thought about so far (Q2).

Summary Review of Mrs Simon's Score:

In relation to the game related to the scientific concept forces Mrs Simon score and scorekeeping attitudes are as follows:

1. She *acknowledged* entitlement to Jessica and all pupils to commitment C2 (E2)
   - (E2) Entitles Jessica to C2
2. She *acknowledged* an *assertional commitment* (C3) and by default entitles pupils (E3)
   - (C3) Forces are needed to *start* things *moving*. (Committive inferential consequence of C1, C2)
   - (E3) Forces are needed to *start* things *moving*. (Permissive inferential consequence of C1, C2)
3. She ends with an *auxiliary move*, which does not change the score, query (Q2)
   - (Q2) What else might they be used for? (Other committive consequences of C1, C2)

GoGAR (move):	(T2) Teachers gives and asks for reasons.
Speech Act (move):	Assertion and Query
Score (statuses):	(E2) Assertional Entitlement
	(C3) Assertional Commitment
	(E3) Assertional Entitlement
	(Q2) Query

Scorekeeping (attitudes):

Teacher:

- Attributes commitment (C2) to Jessica; Entitles Jessica and Class to C2 (E2).
- Acknowledges (C3) and so from her pupils' perspective they are entitle to C3 (E3)
- Attributes an undertaking C4, which may or may not be acknowledged.
- Query seeks to make attributed inferential commitments (C4) explicit, which we see in the pupil's response to 'asking for reasons'

Jessica/Class:

- Acknowledge Entitlement (E2)

Summary Tabulation of Mrs Simon's Score (T2):

A. GoGAR Move: (T2)	Mrs Simon, giving and asking for reasons	(GR^3/AR^3)
B. Speech Act Types	i. Assertion ii. Assertion iii. Assertion iv. Assertion v. Query	(As_1) (Q_2)
C. Score	Assertional Entitlement Assertional Commitment Assertional Entitlement Query	(E2) (C3) (E3) (Q2)
D. Scorekeeping (Mrs Simon)	*Acknowledges* her own commitment	(C1)
	Attributes her class as undertaking commitment	(E1)

(4.) Becky believes forces 'stops things moving'

(B1): ***Becky:*** *Stop things moving.*

Becky responds to Mrs Simon's question, which calls for the articulation of other key ideas related to force. The teacher is seeking more than a simple definition of forces, which would have ended with Jessica's move 'pushes and pulls' (J1/C1). Mrs Simon is aware of the complex norm-governed network of ideas that constitute the meaning of the concept force. Her query is an attempt to draw out their commitments, their inferential reasoning, their understanding in connecting related ideas that constitute their grasp and use of the concept force. Becky in response to Mrs Simons question, gives a reason by asserting other things force do. Her assertion, like Jessica before her, acknowledges her beliefs that forces also 'stops things from moving'. In publicly acknowledging her commitment or beliefs, such acknowledgment can be attributed to her. At this stage of the dialogue, Becky's move makes an assertion committing her to the idea that forces also 'stop things moving'. This assertional commitment, publicly acknowledged is attributable to her by the teacher, the pupils and Becky herself.

Summary of Becky's Score:

A. GoGAR Move (B1)	Becky gives reason	(GR_4)
B. Speech Act Types in (B1)	i. Assertion	As^2
C. Score	Assertional Commitment	(C4)
D. Scorekeeping (Becky)	*Acknowledges* her own commitment	(C4)
	Attributes to her class/teacher as acknowledging commitment	(C4)
	Attributes to her class/teacher as acknowledging default entitlement to C2	(E4)

GoGAR (move): Jessica gives reason
Speech Act (move): Assertion/Avowal (J1)
Score (statuses): Assertional Commitment (C2)
Scorekeeping (attitudes):

- Jessica: Acknowledges her own commitment
- Teacher/Class: Attributes her as acknowledging commitment (C1)

Jessica *acknowledges* an *assertional commitment:*

- (C1) forces are 'push or a pull'

GoGAR (move): Becky gives reason
Speech Act (move): Assertion/Avowal (B1)
Score (statuses): Assertional Commitment (C4)
Scorekeeping (attitudes):

Becky:

- Acknowledges her own commitment (C4)

Teacher/Class:

- Attributes her as acknowledging commitment (C4)

Scorekeeping:

Becky:

Acknowledges an *assertional commitment*:

- (C3) Forces are needed to *stop* things moving.

attributes an assertional commitment to Jessica:

- (C1) forces are 'push or a pull'

Undertakes Entitlements:

- (E1) Forces
- (E2) Forces are 'push or a pull'
- (E3) Forces are needed to *stop* things moving.

Appendix 5: Teacher Consent Form

Institute of Education

Research Title: An investigation of primary science classroom dialogue and pupils understanding of science

Consent Form For Teacher

If you are happy to participate in this study, please complete this form and return to Shone Surendran in person or at the address below.

	Yes	No
I have read and understood the information leaflet about the above research study.	☐	☐
I have had the opportunity to consider the information and what is expected of me. I have had the opportunity to ask questions and have been answered to my satisfaction.	☐	☐
I would like to take part in the following research activities (please tick one or more of the following options): Interviews ☐ Classroom Observation ☐ Audio Recordings ☐ Reflective Journal ☐	☐	☐
I understand my participation is voluntary and that I maintain the right to withdraw my participation, at any time during the research without reason or any consequences.	☐	☐
I understand that in participating in this research study I provide consent for the collection of data for the purposes explained to me. I understand that such information will be handled in accordance with UCL Data Policy and all applicable data protection legislation.	☐	☐
I understand that all research data will remain confidential and that all efforts will be made to ensure that by using pseudonyms that my classroom and I cannot be identified.	☐	☐
I understand that the data gathered in this study will be stored anonymously and securely. I also understand data collected for this study may be used for research purposes including publications and conferences. It will not be possible to identify me in any publications.	☐	☐
I consent to classroom audio recordings and understand that the audio recordings will be stored anonymously using password-protected software.	☐	☐

You will be given a copy of this Consent Form to keep and refer to at any time.
This study has been approved by the UCL Research Ethics Committee:
Project ID number: Z6364106/2018/05/93

Name of participant: ________________________________ Date: __________ Signature: __________________

Name of researcher: ________________________________ Date: __________ Signature: __________________

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Appendix 6: Pupil Information Leaflet

Institute of Education

UCL

Research Project: How do children talk about science?

Information Leaflet for Pupils

Date:___________

Hello,

My name is Shone Surendran. I am doing a research project for my PhD. The project is called “How do children talk about science?”.

I would like to spend time in your classroom when you learn about science.







I would like to watch and listen to your class during science lessons. I would like to listen when you talk to your teacher and friends about science topics and do science investigations.

I might do an interview with you and ask questions about science or I might want to talk to a group of you!

I need to listen really carefully to what everybody says in your science lesson so I will use a digital audio recorder to record your science lessons or other lessons related to science topics. If we have small-group discussions, or an interview I would like to record those too.

It is up to you if you want to take part in this project. You can say YES ☺ or you can say NO ☹ or if you are not sure 😐, you can talk to your teacher or me later.

On the next page, there’s a big empty circle. If you are happy to take part in this project you draw a **smiley face**.

If you don’t want to take part then draw a **sad face.**

You can finish by writing your name. Remember to write both your first and last name. You can then write your classroom name and your teacher’s name. Don’t forget to write the date.

Please return the form to your teacher. If you want to know more, put your hand up and I can come and talk to you. If you like you can talk to your teacher too.

Thank you, so much for reading this letter.

Shone Surendran
PhD Research Student
UCL Institute of Education

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Appendix 7: Pupil Consent Form

Institute of Education

Research Project: How do children talk about science?

Consent Form for Pupils

Date:___________

Your Choice

Would you like to take part in Shone's "How do children talk about science?" Project?

Please draw a smiley face for YES or a sad face for NO. If you are Not Sure draw a neutral face.

Remember to write your first **and** last name (use **CAPITAL Letters** please):

First Name……………..………………………………………………………………

Last Name……………..……..…………………………………………………………

Teacher's Name: ………………………………………………………………………

Class Name: ………………………………………………………………………………………

Date: ……………………………………………………………………………………..

Please return to your teacher as soon as possible

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