What types of science count?

Exploring the formal, informal and hidden curricula in undergraduate medical education, with a particular focus on beliefs about science and knowledge.

Submitted by Judith Lesley McGregor-Harper, to the University of Exeter as a thesis for the
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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signed:

Abstract

Background and Purpose

This PhD thesis is a qualitative research project using interpretive and socio-cultural theories in a case study design. It explores medical students' beliefs about scientific knowledge and the nature of evidence as applied to medicine, at key transition points in their education. This thesis situates current theories and conceptual models of epistemological development from the fields of psychology and education within the emergent field of medical education. Its aim is to provide insights into personal epistemological development, any curriculum barriers to such and provide insights into how students can be better supported, notably in transition periods. It addresses both a gap in the literature and the calls for more research into the development of student epistemologies in professional education.

The thesis key research questions are:

- What are medical students' beliefs and understandings about the nature of scientific knowledge as applied to medicine?
- What curriculum factors appear to facilitate or inhibit medical students' epistemological development, at key transitions?

Methodology

The case study design involved a four phase approach;

- Phase 1: This was a critical discourse analysis of key policy and curricula texts to explore assumptions, inconsistencies or disputes relating to science and scientific content in the field of medical education.
- Phase 2: This was the observation of learning episodes in preparation for Phase 3 involving participants. The purpose of Phase 2 was to situate and ground conversations with participants in real experiences.
- Phase 3: This phase involved task groups and semi-structured interviews with medical students and faculty participants based at the University of Exeter Medical School (UEMS). Task groups and semi-structured interviews

explored individual beliefs about the nature of science and scientific evidence as applied to medicine generally and the Bachelor of Medicine, Bachelor of Surgery (BMBS) curriculum content specifically. This included its contested scientific content and the nature of complexity and uncertainty in evidence based medicine.

- Phase 4: This final phase involved presenting the case study findings to two other UK medical schools to explore the tentative applicability or transferability. The purpose of Phase 4 was to consider how case-specific and context bound the case study findings are.

Findings

Findings suggest there is substantial variation in how medical students and faculty talk about science and evidence in medicine. This is influenced by their experiences of courses studied prior to entering medical school and their maturity in age. Medical students described how faculty informally spoke about the ambiguity within medical practice as clinical decision making, but there were very few reports of faculty explicitly speaking about the uncertain and tentative nature of scientific knowledge underpinning applied medicine.

The bio-sciences were still dominant in terms of curriculum and assessment content. Where science in medicine is defined and approaches to scientific research are stated, formal curriculum documents espouse a narrow and positivistic methodological approach, which serves to perpetuate misconceptions regarding scientific research within medicine and may influence epistemological beliefs about the nature of science within medicine.

Discussion and Conclusions

It is anticipated this case study will afford medical educators and curriculum designers insights upon which to address imbalances, include appropriate content, and reinforce good practice, so that medical graduates are effectively prepared for the challenges of a career in medicine.

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AMK	Progress test of Applied Medical Knowledge
BMBS	Bachelor of Medicine, Bachelor of Surgery
CDA	Critical Discourse Analysis
DoH	Department of Health
EBM	Evidence Based Medicine
EBs	Epistemological Beliefs
FTE	Full-Time Equivalent
GAMSAT	Graduate Medical School Admission Test
GCSE	General Certificate of Secondary Education
GMC	General Medical Council
GP	General Practice/Practitioner
LSRC	Life Sciences Resource Centre
MMR	Measles, Mumps and Rubella vaccine
NHS	National Health Service
OLEs	Observation of Learning Episodes
PBL	Problem Based Learning
PCMD	Peninsula College of Medicine and Dentistry
PhD	Doctorate in Philosophy
PMS	Peninsula Medical School
RCPSC	Royal College of Physicians and Surgeons of Canada
RCTs	Randomised Controlled Trials
SATS	Statutory Assessments in Primary Education
SDL	Self-Directed Learning
TD09	*Tomorrow's Doctors* (2009)
UEMS	University of Exeter Medical School
UK	United Kingdom

Table 1. Abbreviations And Acronyms Used In The Thesis

Chapter 1: Introduction

1.1. Introduction To The Chapter

This PhD is a case study of the undergraduate Bachelor of Medicine, Bachelor of Surgery (BMBS) curriculum at one medical school; the University of Exeter Medical School (UEMS), in the South West of England. This thesis considers the discourses defining medicine as a scientific discipline, the scope of medicine in terms of curriculum design and inclusion of scientific content, and explores medical student epistemologies regarding the nature of scientific knowledge in medicine. The Oxford English Dictionary (2017) defines epistemology as 'the theory of knowledge, especially with regard to its methods, validity and scope, and the distinction between justified belief and opinion.' Assenheimer writes that "epistemological beliefs have a pervasive influence on learning and practice. Understanding these beliefs and how they develop, could play an important role in medical student training and shape later clinical practice" (2016, p.107).

1.2. The Subject Of This Thesis And General Themes

When junior doctors enter the workplace they take their first steps within a profession where they will be expected to engage in complex decision making about patient healthcare. A study by Knight & Mattick (2006) found that individual epistemic development took time and that the participants in the study, second year medical students, demonstrated predominantly simplistic levels of epistemological thinking, leaving three years, within which, to produce graduates ready for complex decision making. This paper argued that the development from lay conceptions of knowledge, where science is considered to be a place of certainty and 'truths;' such as thinking about science in terms of fixed and certain absolutes, to an "understanding of knowledge as being more contextual, contingent and fluid is an important transition for effective medical practice" (p.1085) and that medical students struggle with developing a rhetoric of uncertainty in medicine. This leads them as junior doctors to find decision making difficult and raises the problem of preparing medical students for the notion of medical uncertainty in their career.

Recent studies echo these findings, suggesting that medical students struggle with the perception of being prepared on graduation for clinical practice and specifically with dealing with being faced with complex clinical problems and being aware of their own limitations (Dornan et al, 2009. Morrow et al, 2012. Bull, Mattick & Postlethwaite, 2013. Monrouxe et al, 2017). As yet there has not been any systematic investigation into the development of medical students' epistemological thinking. Assenheimer states that "little is known however about medical students' epistemological beliefs, i.e., their beliefs about knowledge *per se"* (2016, p.107). More research has been called for to unravel and assess the development of student epistemologies in competence based vocational education (Schapp et al, 2009. Kitto, 2004. Van der Sanden & Teurlings, 2003).

Curriculum designers face choices regarding appropriate content of undergraduate medical courses to ensure that, on graduation, junior doctors are prepared for the demands of clinical practice. Commentators express that the curriculum within undergraduate medical education, in terms of scientific content, is contested through competing interests of societal and professional concerns (Whitehead, 2013. Grant, 2010. Maudsley & Stivens, 2000). These commentators observe that there are vogues in curriculum design ebb and flow in response to the dominant concerns of society and the professions and Grant calls for curriculum design to address "where the science base stands" (p.2).

1.3. Medical Schools Regulatory Context

The project and research took place at the University of Exeter Medical School. Although the case study at UEMS is unique, presenting a study at a particular time and place with particular informant participants, UEMS, however, like all other UK medical schools, sets its undergraduate BMBS curriculum according to guidelines and policy statements from the General Medical Council (GMC). All UK medical schools are subject to inspection by the GMC in assessing how each medical school interprets and complies with setting and delivering a curriculum that meets the outcomes and competencies laid out in the current GMC competency standards document *'Promoting Excellence: Standards for Medical Education and Training'* (2015). Should the GMC assess that a medical school does not reach the standards of medical education, it has the power to challenge the existence of the educational institution.

At the time of the start of the study, in 2013, the key GMC guidance document for the outcomes and standards of medical education was Tomorrow's Doctors (2009); now updated in 2015 as standards covering both undergraduate and post-graduate medical education. There were three overarching intended outcomes for graduates in Tomorrow's Doctors [TD09]. These were:

- The doctor as a scholar and a scientist
- The doctor as a practitioner
- The doctor as a professional

No particular outcome was explicitly apportioned dominance in this guidance document.

My thesis focused upon the TD09 outcome 'the doctor as a scholar and a scientist', the outcome that encompassed knowledge acquisition in the scientific disciplines considered to be relevant to medical practice. TD09 stated that medical school curricula would be "structured to provide a balance of learning opportunities and to integrate the learning of basic and clinical sciences, enabling students to link theory and practice" (Criterion 83, TD09). In addition to basic and clinical sciences, TD09 also listed psychology and social sciences as relevant sciences for inclusion in undergraduate curricula (p.14 – 16). The outcome 'the doctor as a scholar and a scientist' concerns issues related with personal epistemic development regarding scientific knowledge and research in medicine.

Medical student applicants applying to UEMS are required to demonstrate, as part of the application process, a strong background in the natural sciences, which includes chemistry, and in addition, either biology or physics. Therefore the natural sciences are viewed as directly relevant to the study of medicine at UEMS.

1.4. Project Design

The research project is qualitative in design. The theoretical perspectives informing the research design are from socio-cultural theories in combination with models of personal epistemological development that were drawn from psychological perspectives. The design of the project is presented as a case study, which considers the subtle effects of power and the hidden curriculum that are socially constructed. The project assumes that medical education is a complex intervention. The dimensions that make up this complexity include the range and different learning environments and teaching methods (medically qualified and non-medically qualified staff, multi-disciplinary healthcare professional interdisciplinary learning environments; lectures, clinical placements and guided small group learning; medical student differences in terms of age, maturity, academic and cultural backgrounds; a range of assessment processes throughout the course and ultimately registration accountability to the professional regulator). Mattick, Barnes & Dieppe argue that by "considering medical education a complex intervention for research purposes may help researchers to gain new insights and design new approaches to its evaluation" (Mattick, Barnes & Dieppe, 2013, p.771). In this thesis it is asserted that complexity leads to inherently unpredictable outcomes. I have adopted an interpretivist analysis approach in this project, within constructivist socio-cultural lens frameworks. Through these methods the complexity within in the project will be revealed. The case study adopts a four phase approach;

- Phase 1. This phase focuses on the formal curriculum. It involves a critical discourse analysis of key education policy and undergraduate medical school curriculum documents from the GMC and the University of Exeter Medical School (UEMS). The focus is upon epistemology and the contested student curriculum in terms of its scientific content.

- Phase 2. This involves observations of learning episodes in the BMBS programme. The aims of the observations are to experience the formal and informal curriculum to understand how the intended formal curriculum (in documents) plays out in practice. Phase 2 will also serve to develop question topic guides to use in carefully facilitated in depth semi-structured interviews and/or focus group sessions with research participants in Phase 3, to give insights into medical student experiences beyond the timetabled curriculum.

- Phase 3. This involves medical student and faculty participant task groups and/or semi-structured interviews. The purpose of the interviews or focus groups is to explore how medical students and faculty members voice their personal epistemologies regarding the nature of scientific knowledge and their views regarding suitable scientific content in the undergraduate curriculum. Medical student participant sessions explore shifts in epistemologies after key undergraduate transition periods, if any, and how medical students think these shifts are facilitated. This phase also explores how medical students are influenced by faculty and other role models, by exploring the informal or hidden curriculum. Medical students invited to take part in the research were those medical students undertaking transitions; those in Year One and Year Three of the BMBS programme. Year One medical students were included as they transitioned from secondary education to a university medical school setting. Year Three medical students were included as they were beginning the journey of transitioning from being based primarily in a university to a healthcare setting. With faculty participants I also explore the contested BMBS curriculum in terms of scientific content, giving further insight into the hidden curriculum.

- Phase 4. This involves discussion with two academics working in medical education regarding the application and transferability of my findings to two other UK medical schools.

1.5. The Thesis Research Questions

This thesis explores the development of medical students' beliefs about the nature of knowledge, particularly scientific knowledge and research evidence, at two time points, representing key transitions, in the undergraduate medical degree and the influences from the formal, informal and hidden curriculum on this will be sought.

My key research questions are as follows:

- What are medical students' beliefs and understandings about the nature of scientific knowledge as applied to medicine?
- What curriculum factors appear to facilitate or inhibit medical students' epistemological development, at key transitions?

1.6. Structure Of The Thesis

This thesis is presented in nine chapters. Following this introduction, Chapter 2 provides definitions and an overview of curricula within medical education and reviews the literature about research into student epistemologies, focusing on studies from education, psychology and medical education. The history of research into student epistemologies came from education; methodological approaches have been dominated by psychologists. The literature review situates current theories and models of personal epistemological development developed in the fields of psychology and education within the relatively unexplored domain of medical education, considering the relevance to my research questions. Chapter 3 describes my methodology and theoretical framework, including the methods for data collection and analysis. In this Chapter I present the key ethical considerations for my research. Chapter 4 presents the findings from the critical discourse analysis of key undergraduate policy and curricula texts. I track and contrast medical student undergraduate guidance documents from the UK regulator and those selected from the rest of the world. The critical discourse analysis probes underlying assumptions of policy documents, specifically implied or explicit discourses regarding science, scientific method and scientific research and the values attributed to such epistemologies, and reveals the relative dominance assigned to subject matters. In Chapter 5 I present the inductive data-led analysis findings with medical student participants in task groups and semi-structured interviews and faculty participants in semi-structured interviews. In Chapter 6 are the findings from theoretical perspectives of epistemological development derived from educational and psychological research and informed by the participant task groups and semi-structured interviews. I present these finding by plotting diagrammatically where the participants sit in relation to models of epistemological development. Chapter 7 describes the findings reached from interviews with two clinical academics at two other UK medical schools with whom I discussed my initial research findings for their consideration of any applicability of transferability of the findings to their setting. Chapter 8 provides a discussion of the findings from Chapters 4, 5, 6 and 7, placed within the contexts which I have outlined in this introduction. Finally, in Chapter 9 I present the concluding reflections and recommendations to medical educators and curriculum designers.

1.7. Funding For The Research

This PhD research project was funded by the University of Exeter Medical School.

1.8. Summary Of The Chapter

Through a case study at UEMS, structured by the research questions in section 1.5, the study aims to deepen a theoretical understanding of how medical students understand the role of science in medicine, by exploring how this understanding relates to their personal views about the nature of science. Without research into the epistemological development of medical students, medical schools may fail to nurture future professionals who can make appropriate decisions in complex environments; interactions between students and educators may not be maximised, and may be frustrating and even damaging; and the extent to which education policy translates into practice on the ground will remain unclear. It is hoped that the findings of this PhD will afford medical educators and curriculum designers' insights upon which to address imbalances, include appropriate content and reinforce good practice, so that medical graduates are effectively prepared for the challenges of a career in medicine. It is anticipated that outcomes from the study will provide insight into how and when educators need to intervene to improve student epistemological development, in order to nurture professionals who are capable of complex decision making.

Chapter 2: Literature review

2.1. Introduction To The Chapter

The thesis research questions broadly concern preparedness for practice in medicine within the context of undergraduate medical education. The nature of this research project concerns epistemologies about scientific knowledge in medicine. This research is important to better understand views about the nature of science in medicine in order to develop curricula that prepare junior doctors well for research and decision making roles in a complex clinical environment.

In the UK, undergraduate medical programmes are regulated by the General Medical Council. Prior to revision into a joint document for undergraduate and postgraduate medical education (implemented from April 2016) the GMC standards and outcomes guidance for undergraduate medical education was *Tomorrow's Doctors* (2009). This publication's foreword stated that changes were made from previous editions in response to concerns about scientific education. *Tomorrow's Doctors* (2009) had three overarching domains: The doctor as a scholar and a scientist: The doctor as a practitioner: The doctor as a professional. The doctor as a scholar and a scientist domain broadly deals with themes about knowledge acquirement, the doctor as a practitioner domain broadly deals with themes about skills acquisition and the doctor as a professional broadly deals with themes about professional behaviour. My research focusses on knowledge development. The current GMC standards and outcomes document, *Promoting Excellence: Standards for Medical Education and Training* (2015), is a simplified set of standards that leaves curriculum design largely to individual medical schools. The document, unlike previous versions of *Tomorrow's Doctors,* has very little to say about scientific content in undergraduate curricula. This thesis has therefore focused upon the GMC documents that do have something to say explicitly in terms of epistemology on the nature of science and scientific research in medicine.

Published medical research between 1988 – 2010 has been skewed toward the skills and behaviour outcomes in *Tomorrow's Doctors* (linked to performance and assessment concerns), less so regarding knowledge acquisition (Rotgans, 2012). This shows a gap in research concerning the topic of this thesis.

Theme	Number of articles published	Concerned with acquisition of skills, knowledge or professionalism (as behaviour)
Issues in student assessment (reliability, validity, multiple-choice questions, self-assessment, assessors, use of portfolios)	1635	Mostly concerned with skills
Clinical skills training	1338	Mostly concerned with skills
Clinical clerkships	1284	Mostly concerned with skills
Problem-based learning	760	Mostly concerned with skills
Community-based training	626	Mostly concerned with skills
Clinical competence assessment	553	Mostly concerned with skills
Teaching the clinical sciences	512	Mostly concerned with the clinical phase of education and skills
Communication skills training	387	Mostly concerned with the clinical phase of education and skills
Student characteristics	390	Mostly concerned with behaviours
Objective structured clinical examination (OSCE)	367	Mostly concerned with skills
Teaching the basic sciences	314	Concerned with knowledge from content delivery standpoint rather than theoretical aspects of science teaching or epistemologies
Nature of clinical reasoning	268	Mostly skills and some knowledge

Table 2. Top Twelve Themes Within Medical Education Research 1988 – 2010: Assessment Of 10,168 Published Article Abstracts (adapted from Rotgans, 2012).

Even research that has focused on knowledge has mainly focussed on clinical and not pre-clinical education. Most of these papers have originated from North America and look at curricula there. An explanation for the dearth of research in medical education regarding knowledge development, or the nature of knowledge, may be due to a lack of funding for this type of work, with literature to date being dominated by concerns about pragmatic aspects in medicine, at the expense of theoretical debates. However, this PhD represents protected researcher time, which most clinicians simply do not have. It therefore allows an opportunity to step back and consider what might be some of the reasons why medical students think the way they do and help to understand why junior doctors frame decision making in the way they do. Rotgans calls for medical education to move beyond “effectiveness driven research”, to “a more theory and discovery driven approach” (p.515). He also notes that research exploring areas such as “what is the nature of knowledge used in diagnostic expertise” are “largely unresolved and deserve resolution to improve medical education” (p.524).

2.2. Description Of Science And Scientific Methods In Medicine

Medicine is described as having a scientific base. A simple Google search for a definition of medicine leads to web-based dictionary definitions that describe medicine as having science as a fundamental defining characteristic. For example, biology-online.org defines medicine as *a scientifically-based discipline dedicated to the prevention and treatment of disease and injury*. Similarly the English Oxford Living Dictionary on-line webpage defines medicine in terms of *the science or practice of the diagnosis, treatment and prevention of disease.* However, accepting that medicine *is* a scientific discipline does not mean that there is consensus regarding *what* being scientific in medicine means.

The terms *science* and *scientific* are often taken for granted and used in different ways by different authors, thus providing valuable insights into the epistemologies of the people deploying these terms. For example, if science is described as something that is ‘proven’ or ‘factual’, this says something about beliefs about the status of knowledge claims (that the knowledge is fixed and absolute) and also the status of the discipline that such claims are attached to (in terms of ‘reliability’).

The scientific approach to the production of knowledge in medicine and the methodological basis is contested. The Oxford English Dictionary (2017) takes a positivistic approach in defining science as *the intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment.* This is positivistic as it defines scientific enquiry in terms of quantitative methods employing observation and experimentation, implying that a stable reality exists, which can be sought and (at least imperfectly) defined. The most recent guidance document for undergraduate medical education in the UK to include a definition of scientific methods was in *Tomorrow's Doctors* (2009). The document did so in terms of *'…including the principles of measuring biological functions, the evaluation of scientifically established facts and the analysis of data'* (p.83). This is also a positivistic stance, taking empiricism or the validating and measurement in quantative research, as its definition and endpoint. Part of this thought style is a set of criteria that identifies trustworthy knowledge, usually identified as 'true' and 'objective,' as 'scientific'. Rochel de Camargo Jr (2002) argues these claims are strongly associated with truth and objectivity claims about bio-medical knowledge and its scientific basis. For Rambihar (2000) positivistic and empiricist approaches to understanding scientific knowledge is representative of "a puzzle solving approach, with uncertainty managed and values unspoken" (p.1730).

The definition of science supplied by The Science Council (2017), as *the pursuit and application of knowledge and understanding of the natural world following a systematic methodology based on evidence*, espouses evidence based research as an epistemological approach, rather than an intended outcome of establishing and interrogating facts. Indeed, Whitehead (2011) observes that demonstrating that something is a 'fact' does not make it scientific (p.56). The Science Council definition attempts to bridge both ways of thinking about knowledge and practice by tying this to evidence based practice. However, it is useful to be wary that evidence based practice is a specific way of thinking and it has been argued that there is often lack of theoretical discussion behind empirically driven 'evidence based medicine' (EBM) (see Cohen & Hersh, 2004) and thus some critics are alert that EBM is a synonym for empiricist positivistic scientific methods in medicine. Ng et al (2015) claim that EBM "stems from an epistemology that considers experimental [scientific] research knowledge to be of primary value" (p.463).

The final definition of science that I put forward is one attributed to Pierre Emile Duclaux (1840-1904), French biochemist/bacteriologist, that *science is a series of judgements, revised without ceasing.* This definition holds within it something of the personal and subjective nature of scientific enquiry, which Whitehead (ibid) associates with Flexner's discourse of the inquiring approach to science and the notions of the 'person' of the scientific physician and science being "not merely a tool to be used by physicians; rather, a scientific approach is a way of being" (p.57). Here Whitehead is in agreement with Rambihar (ibid) that a scientific approach is one that "recognises irregularity, subjectivity, and uncertainty as intrinsic and fundamental" (p. 1730). Whitehead argues that doctors practicing medicine do so scientifically; they observe, experiment and make judgements when 'doing' the science, but also are in a state of inquiry about situations of uncertainty when 'thinking' about science. For Rambihar this contextual and changing aspect of the nature of evidence in medicine is crucial. He concludes by calling for more discussion, and debate on this subject, "since it relates to fundamental issues in medicine, and the meaning and use of science and evidence in general" (p.1730).

2.3. Medicine As A Scientific Discipline

As Rochel de Camargo Jr (2002) points out, a mainstay of medicine is not the *production* of knowledge, i.e. not science in terms of knowing, but its *application* in a variety of situations, according to ethical principles (science in terms as doing, and the desire to achieve permanence of desirable health results).

There has been, for over 150 years, on-going debate about appropriate scientific content for inclusion within the undergraduate medical curriculum. In 1858 the English parliament passed the Medical Act. In England, prior to the 1858 Medical Act, students of medicine learnt their craft by serving apprenticeships alongside the apothecary, surgeon or physician (Thompson, 1960). This tradition could be traced back to the classical traditions of Greece and Rome, Burnham (1999) argues in the two centuries leading up to the 1858 Act it was important for physicians to emphasise their relationship to classical traditions as a venerated and authoritative scientific model. According to Sir Clifford Allbutt, writing in 1905, a mediaeval division of medicine into medicine and surgery "had its roots not in nature, not even in natural artifice but in clerical, feudal and humanistic conceits" (in Finch, 1958, p.326). Writing about what types of sciences acquire authority and status Burnham (ibid) argues that conceiving of medicine in terms of specialities assisted in emphasising the distinctive scientific expertise by those practicing in the separate fields.

The 1858 Act was significant as it established a statutory body for the regulation of medicine. This statutory body became formally known as the General Medical Council in the 1950 Medical Act (Hansard HL. 18 April 1950). The 1858 Act gave the statutory body the role of overseeing a curriculum for the teaching of students of medicine in partnership with teaching hospitals (and later Universities). Through the creation of an annual medical register emphasis was established for those considered 'qualified' and 'unqualified' to practice medicine (Thompson ibid). In his paper on the history of medical practitioners and professional historians as writers of medical history Burnham argues "the history of medicine as the history of scientific discovery served the professional purpose of helping to exclude from the profession practitioners who did not have modern training" (ibid, p.253). He further adds this "simultaneously, served the purpose of portraying medicine as progressive and scientific and, hence, authoritative" (ibid. p.253). In the writings of physicians, such as Bass (1889), Garrison (1929) and Sudhoff (1926), in the late 19th and first part of the 20th Century, there are conscious attempts to embed Western medicine as scientifically culturally important.

Thompson (ibid) states the aim of the 1858 Act was to produce "competent practitioners" but where "cultivation of scientific method as the basis for progress" stood neglected. Even up to the immediate post-war period Finch (ibid) argues regulation and curricula for students of medicine continued to adopt a model of vocational training as the preferred method for producing qualified doctors ready to "proceed to independent practice immediately after registration." Finch believes students "subsequently tended to concentrate on factual data, owing to the growing congestion of the curriculum resulting from the increase of specialism and other causes."

The significant event in the twentieth century regarding change in the education of medical students came in 1910 with the publication of the influential Flexner report (Flexner, 1910). The American Medical Association asked the Carnegie Foundation to commission Flexner to carry out a review into medical education in the United

States and Canada. The report is remembered for creating a single model for medical education, increasing the length of study time medical students spent as undergraduates and strengthening ties between universities and clinical instructional hospitals. Cooksey and York (1999) reported that Flexner "emphasised the need for hands-on patient experience as a required part of the medical school curriculum. The practical consequence of this review was the recommendation that each medical school establish a stable relationship with a pedagogically controlled hospital" (p.23). Cooksley and York argue Flexner's model championed bio-medicine as the justification for clinical teaching experience of anatomy and physiology within teaching hospitals. They tell us, "the practice of medicine has its scientific base in bio-medical concepts of the disease process and applies this to the diagnostic, treatment and preventative aspects of medical care" (ibid, p.28). Biases toward bio-medical sciences in the Flexner report influenced medical school curricula and were being noted and written about as early as the 1930s. Pemberton's (2002) recollections as a member of the Society for Social Medicine during this decade suggests social medicine and public health were side lined within the medical curricula due to "domination of the curriculum by the teaching hospital consultants whose incomes depended upon private practice and who determined the types of patients admitted to teaching hospitals" (p.342). For Pemberton, as a young doctor at this time, social factors in the prevention of treatment of illness, "were rarely, if ever, discussed by our teachers" (op cit).

When junior doctors enter the workplace they take their first steps within a profession where they will be expected to engage in complex decision making about patient healthcare. This means application of the scientific knowledge they have learnt underpinning medical presentations. Matthews (in McComas, 1998) argues, "the ability to distinguish good science from parodies and pseudoscience depends upon a grasp of the nature of science" (p.xiv). Therefore it is reasonable to ask, what does a good grasp of the nature of science lead to in practice as a junior doctor? Will it assist them in being able to apply evidence based medicine by using critiquing skills to assess evidence, guidelines and literature to inform practice? Would it help junior doctors feel better able to make a decision because they feel more comfortable with notions of scientific uncertainty and therefore medical uncertainty and less restrained by notions of singular treatment plans, making them confident to go off protocols and guidelines if they felt these were the justifiable for the patient's best interests? Would it benefit them in the notion of being able to move conceptually from science as a set of generalisable truths about populations, to practicing medicine as the art of assessing and treating variations in individuals and their personalised health needs?

2.4. The Formal, Informal & Hidden Curricula In Undergraduate Medical Education

Why study the curriculum in undergraduate medical education to explore personal beliefs about the nature of and role of science in medicine? Firstly, curricula may be formal, informal and hidden. Formal curricula are explicit statements, usually in texts, about intended aims and objectives, course content, course outcomes, intended experiences and processes (including methods of teaching delivery and assessment) of an educational programme. Formal curricula include learning that is likely to take place within an institution "as a result of instruction" (Swanwick, 2005, p.859). In this thesis constructed social discourses regarding the scientific status of medicine, approaches to conducting scientific research in medicine and what types of sciences 'count' within the undergraduate curricula will be explored critically through Foucauldian discourse analysis of key formal curricula texts.

Informal curricula is learning that may be planned but also unscripted or emergent and in the context of undergraduate medical education, such as that which may occur, for example, during clinical placements on hospital wards or in GP surgeries or be delivered via medical society involvement. Hidden curricula are wider than aspects of formal or informal curricula and refer to implicit learning and unintended consequences that shape the socio-cultural normative values within curricula (Gofton & Regehr, 2006. Hafler et al, 2011. Mossop et al, 2013). In medical education hidden curricula may include looking to assessment cues in order to gain a competitive edge over peers and determine from this what topics really count (Lempp & Seale, 2004). The hidden curriculum may also identify role modelling by faculty in relation to how doctors think, and act and 'should' be, or expose stereotyping of the status of differing types of scientific research. There may be tacit and latent socio-cultural influences within hidden curricula, for example, from TV medical dramas, shaping what perceptions medical students associate with medicine and medical specialities. The formal, informal and hidden curriculum make up a meta-discourse within medical education. It is important to consider formal, informal and hidden curricula individually and as a whole in shaping personal epistemological development regarding science and scientific knowledge in medicine. Identification of the interplay and reinforcing influences, dissonances and power imbalances through interpretist or socio-cultural constructivist lenses can aid in sensitising educators to the messages medical students receive and assimilate about the individual curriculum being learned.

2.5. Studies Of Personal Epistemological Belief In Education

This thesis' main concern is with the personal epistemological beliefs of medical students, in particular beliefs about science and the nature of scientific enquiry in medicine. The literature review will conclude with a review of studies into personal epistemological development in medical education. This is an emergent field of research, with roots in studies from general education concerning personal beliefs about knowledge and learning.

The first research into student personal epistemologies emerged from the field of general education, from the 1950s onwards. William Perry's work was the key early research regarding personal epistemological beliefs. In the 1950s and the 1960s he interviewed male liberal arts students about their learning experiences whilst at Harvard University. Longitudinal studies over several years (Perry, 1970) led Perry to refine an original nine positions of experiences to four categories, *called the scheme of intellectual development*, about the nature of knowledge and learning relating to cognitive, ethical and identity development. Perry concluded that the University students moved sequentially during their time at University, because of experiences both inside and outside of the University, through worldviews categorised as *'dualism'; 'multiplicity'; 'relativism'*; and *'commitment within relativism'*. Individuals who held *dualistic* views about the nature of knowledge believed that absolute truths (right/wrong) exist and could be transmitted to an individual from an authority or expert. Next, when individuals began to conceive of knowledge in a *multiplistic* way, they conceded that as well as absolute truths, there were some things that could not be known with any certainty. Such individuals believed that knowledge comprised both personal opinions and ultimate truths. The next position*, relativism*, constituted a major shift in personal epistemological thinking because individuals considered that knowledge was a reasoned construction of meaning rather than relying on intuition or personal opinion, although initially this may have occurred in some contexts only. Absolute truths could no longer exist for them because truth was considered to be relative to individuals' personal interpretations of experiences. In the final positions related to *commitment*, relativistic thinking was still a feature, but particular beliefs were more valued than others and were committed to in a flexible manner. Perry's *scheme of intellectual development* influenced subsequent models of personal epistemological development.

In the field of educational research, studies have also considered the impact of teachers' epistemological beliefs about the nature of science on their student's epistemological intellectual development. Early studies by Anderson (1950) and Behnke (1961) concluded that teachers tended to possess serious misconceptions about the nature of science. Solomon, Scott & Duveen (1996) concluded that teachers' personal views on the nature of science often did not match the epistemological viewpoints espoused by national curricula documents, but teacher viewpoints influenced students nonetheless. For the authors there was a mismatch between national curricula that stressed the importance of students learning to appreciate uncertainty of scientific evidence and teachers simplifying the nature of scientific evidence to express an epistemology that evidence was constant and reliable. For Water-Adams (2006) teachers' view on the nature of science was closely associated to their general pedagogical views about personal teaching goals and beliefs. This could lead to 'mixed-epistemologies,' depending upon how confident teachers felt about their teaching role, the aims of the curriculum and perceived appropriate pedagogical approaches. The paper concluded the teachers, when *doing* science, generally promoted a hypothetical-deductive model of scientific method, because this was "the received wisdom of their training" (p.926), but that the teachers in the study in interviews expressed more relativist models of intellectual and scientific thought (when *thinking* about science). Such studies are important as they expose potential tensions within and between individual educators and official curriculum on the development of student epistemologies.

There have been numerous studies related to students' conceptions of the nature of science. According to Lederman (1992), various studies found that students do not possess 'adequate' conceptions of the nature of science, or that studies show that most students tend to have naïve views of the nature of science even when teachers have 'appropriate' views of the nature of science (Sun Young Kim, 2007). For example, Linn, Songer & Lewis (1991) conclude that "students frequently believe that science is a collection of facts and that the best way to learn science is to memorize those facts" (p.729). There seems to have been a particular resurgence in studies of student views of science conceptions in the 1990s and onwards, fuelled by attentiveness by psychologists in developing models of epistemological development. Studies have focused across all aspects of schooling, such as primary school (Tytler, 1998), elementary school (Conley et al, 2004. Solomon, Scott & Duveen, 1996), and university students (Marton, Wen & Nagle, 1996. Khine & Hayes, 2010); the last two studies mentioned focussed on cultural differences in perceptions about the nature of scientific knowledge. The methodological approaches used in studies have been varied. For example, the use of self-reporting questionnaires (Conley et al, ibid), attitudes survey (Khine & Hayes, ibid), semi-structured interviews across two sites as independent studies (Marton, Wen & Nagle, ibid), multi-method designs, such as by Tytler (ibid), using observation of scientific experiment with post-reflective discussion and semi-structured interview and Solomon, Scott & Duveen, (ibid) who over a three year longitudinal study used questionnaires, observation of teaching sessions and semi-structured interviews. However, not all studies are designed to capture the real-life experiences of the study participants. Solomon, Scott & Duveen (ibid) used a questionnaire for 14 – 15 year old students to investigate personal epistemologies about science, but the questionnaire design was framed like a knowledge test. One must consider if younger participants framed responses in such a way as to try to impress upon researchers the 'correct responses'. This is also a criticism of 'paper and pencil' assessments of personal epistemologies shared by Lederman, Wade & Bell (1998a), who believe that such methods intended for revealing personal epistemological beliefs are tainted by inauthenticity; both by participant and by assessor who have their own biases. It can be argued that inauthenticity is more likely to be overcome by more 'naturalistic' explorations of personal epistemologies, such as in the use of semi-structured interviews grounded in questioning about personal experiences of learning about science and thus in my project design I have included Phase 2, the observation of learning episodes, to inform the creation of authentic curriculum experiences on which to base semi-structured interview questions for Phase 3 of the project data collection.

2.6. Models Of Personal Epistemologies Post-Perry

Models of personal epistemological development were fashioned from educational research, then further refined and developed by psychological researchers (Hofer, 2001, Khine & Hayes, ibid). Initial models of epistemological conceptual change about scientific research came from theoretical philosophy of science perspectives (see Kuhn, 1970 and Lakatos, 1970). However, it was through psychological perspectives that models of conceptual change moved from claims about cultural paradigmatic shifts affecting large groups, to focussing on personal perspectives, notably from student perspectives and in domain specific frameworks.

Current methodological approaches used in personal epistemology research have roots in cognitive development, which has been dominated by psychologists, with other social science approaches neglected. It should be noted that researchers and models of epistemological development often define epistemological beliefs differently in studies. However, Schommer (1994) says that "in general, researchers of personal epistemology are interested in what individuals believe about the source, certainty and organisation of knowledge" (p.293). For Hofer, (ibid), the aim of personal epistemology research is to "help us understand how individuals resolve competing knowledge claims, evaluate new information, and make fundamental decisions that affect their lives and the lives of others" (p.354). Researchers also tend to use the terms 'beliefs' and 'knowledge' interchangeably. In this thesis it is intended to use the term 'knowledge' as implying justifiable and supported claims, in a way that beliefs may not be.

Perry's *scheme of intellectual development* was remodelled by King & Kitchener (1994) into a seven stage model of belief about knowledge and reality, which encompassed reflection on knowledge limits, certainty of knowledge and criteria of knowing. This model came from studies (see Kitchener, 1983. King et al, 1983) into the epistemic assumptions that underlie reasoning, focusing on epistemic cognition;

specifically the ways people understand the process of knowing and how they justify their beliefs. The authors used a methodological design of ill-structured problems that demanded a problem solving approach to situations of complexity and uncertainty. According to Hofer & Pintrich (1997) both Perry and King & Kitchener make “no assumption that individuals fit only one stage at any time” (p.101). Schommer’s contribution to models of epistemological development (Schommer, 1990. Schommer, 1994b) was a four dimension construct labelled ‘epistemological beliefs,’ developed from research using a questionnaire about epistemological beliefs to assess student’s ‘innate ability’, ‘quick learning’, simple knowledge’ and ‘certain knowledge’. Schommer’s research indicated that beliefs in higher education settings evolved over time and that the higher the education level the more likely students were to believe that knowledge is constantly evolving and highly complex (Rodriguez & Cano, 2006).

Hofer (2000) identified two common themes in the models of Perry, King & Kitchener and Schommer. The first was regarding the ‘nature of knowing’ (what one believes knowledge is), assessed in all models through degrees of beliefs about certainty and simplicity of knowledge. The second theme was regarding the ‘nature or process of knowing’ (how one comes to know things or how students become makers of their own knowledge) assessed through statements about sources of knowledge and justification of knowledge. This theme captured aspects of the contextual and constructed nature of knowledge. These two themes are also present in the Nott & Wellington (1993) *nature of science profile*, developed from science teaching (especially physics) to assess statements made by teachers regarding verisimilitude, constructionism, empiricism and the role of theory in the nature of science. The aim of this assessment and profile was for teachers to consider how they view processes (methods) in science and how this influenced the taught content of their lessons.

In terms of carrying out research into personal epistemologies in educational institutions and reflecting upon methodology, Schommer-Aikens (2004) has concluded that if pen and paper epistemological assessments are used, this is enriched by other institutional data such as interview, observations and document analysis to “provide a more holistic understanding of personal epistemology” (p.23). This stance is supported by Baxter Magolda (1992), who urged researchers to provide a rich description of the institutional context, consistent with qualitative research design, in order to enable judgements about the transferability of any findings.

From studies using epistemological framework models a number of claims about personal epistemological development in educational settings have emerged. The first is that personal epistemological beliefs in education are influenced both within the educational setting and outside of this context (Schommer-Aikens, 1994). The second is that assessment of personal epistemological belief can be used as an indicator of educational performance (Rod Rodriguez & Cano, ibid). Thirdly, that there are often mismatches between epistemological statements made in official curricula, supporting documentation of this and in the teacher's beliefs who deliver the curricula (Nott & Wellington, 1999). Fourthly, that beliefs may be domain specific (domains may include individual topics within a curriculum) (Schommer-Aikens & Duell, 2013. Hofer, 2000). And finally, that within scientific curricula nature of science teaching is often neglected, taught informally and/or dependent upon the initiative and personal interest of the individual teacher (Nott & Wellington, ibid. Solomon, Scott & Duveen, ibid).

2.7. Studies Of Personal Epistemological Beliefs In Medical Education

In my literature search there was one key paper addressing medical student epistemology and the taught scientific curricula, using models of epistemological development to provide a theoretical underpinning for the research findings. This was the study by Knight & Mattick (2006), who used semi-structured interviews to study medical student's personal epistemological thinking in their second year of training at a UK medical school. Knight & Mattick summarised their research into second year medical students' beliefs by concluding, "whilst responses were varied, students appeared to express predominantly simplistic levels of epistemological thinking according to current developmental models of personal epistemology" (p.1084). The authors also noted previous research suggested "personal epistemologies can be affected by educational context" (p.1086). This PhD thesis builds upon Knight & Mattick's research.

There have been two more recent studies in the field of medical education and healthcare that have used theories of epistemological development in their studies. A study by Assenheimer et al (2016) examined epistemological model domain factors of certainty of knowledge and justifications for knowing in two groups of first year medical students in Australian and Malaysian medical schools (totalling 239 participants). The aim of the study was to see if there were cultural differences in epistemological beliefs apparent between the two medical schools. Their findings were that first year medical students in the Australian medical school seemed to indicate more sophisticated and flexible belief systems, associated with greater expression of relativism when thinking about learning “situated and validated in the science disciplines” (p.108). The method of data gathering in this study was a self-assessment questionnaire distributed to medical students after a lecture session. Although the authors state completion was entirely voluntary, the possibility of expectation of joining the study because of peer and teacher pressure must be considered. The second recent study was by Bientzle, Cress & Kimmerle (2014) and concerned epistemological development within physiotherapists, using a framework of epistemological belief model. The method of data collection was also an epistemological beliefs questionnaire about physiotherapy and medicine, concentrating on bio-medical and psychosocial therapeutic health concepts. The questionnaire considered participant responses regarding knowledge in terms of its certain and absolute nature, or a variable, constructed and tentative nature. The participants were year one, ‘advanced students’ and professional physiotherapists, with 167 participants in total. The study also considered if knowledge appeared to be domain specific. The findings appeared to be that physiotherapy students developed more sophisticated constructs of knowledge (associated with variable, constructed and tentative view of the nature of knowledge) as they progressed in their profession, but that there were domain specific beliefs, such as dualistic epistemological belief systems emerging by physiotherapists regarding the nature of knowledge in medicine and physiotherapy. The knowledge constructs concerning physiotherapy were more associated with being believed to be variable, constructed and tentative than medical knowledge. The authors conclude that physiotherapists were more likely to view their discipline as orientated to bio-psycho-social models of epistemological belief, and this is suggested by the authors as more associated with constructed and uncertain models of knowledge. Bio-medical knowledge was more likely to be viewed in more naive and absolutist terms by the physiotherapy students.

Studies prior to Knight & Mattick's (2006) paper on personal epistemology within medical education included Lempp & Searle (2004), who described how they interviewed 36 medical students to explore the hidden curriculum in undergraduate medical education by researching medical student's perceptions of teaching. This paper was a critique of the culture of an educational establishment, specifically in relation to hierarchies, a competitive atmosphere and bullying. Although this research is of interest for a Foucauldian scholar, with respect to customs and rituals within an institution, the paper did not present any findings regarding a discussion of undergraduate medical curricula. The research also did not assess medical student's understanding of scientific knowledge. However, it did highlight the importance of role models and factors beyond the formal curriculum.

Two research papers, one by Koksal & Koksal (2012) and one by Peña, Paco & Peralta (2002), looked at doctors' beliefs and their understanding of the basis of scientific knowledge. Koksal & Koksal concluded from questionnaire returns, using a small sample of four participants, that Turkish graduate medical students showed many misunderstandings about "universally accepted one way to do science" and that the participants did not "have sufficient understandings to overcome problems on which making informed decisions is needed" (p.26). Similarly, Peña, Paco & Peralta, in their questionnaire survey of 161 physicians in Peru, reached a conclusion from survey replies that overall "there appear to be deficiencies in the knowledge of scientific theoretical foundations among physicians' and that 'no respondents knew the philosophical presumptions of science" (p.1) The findings were concerning to the researchers who believed that "scientific knowledge subsumes a set of epistemological, logical and ethical foundations" (loc cit). Neither paper commented directly upon the types of curricula within medical training that the doctors undertook, nor therefore how had this influenced or impacted upon doctor's beliefs.

Inam et al (2003) concluded that nutritional education modules within the curriculum for medical students at a university in Pakistan changed student beliefs regarding the heath giving or health detracting effects of foods seen as having inherent hot or cold properties. This paper argued that knowledge gained by students enabled them to articulate ‘less myths’ about health effects of restricting or encouraging uptake of certain foods to manage disease conditions, and this could be attributed to students’ progression through the taught curriculum. The paper’s research method used a self-administered questionnaire to all 109 students in years one and five of their medical training, of which 106 completed the questionnaire. The returns represented participant’s personal views. The approach was not critical in the sense of exploring the knowledge underpinning belief systems. The study simply concluded whether student views about the nutritional benefit of certain food were ‘right’ or ‘wrong;’ with ‘wrong’ responses being consigned to ‘myths’ of cultural perception and not based on ‘right’ scientific evidence. In this study design is the epistemological assumption that science evidence sits independent of cultural constructs and that this is a desirable attribute of the nature of scientific enquiry.

What is found in this review of literature within medical education and healthcare are studies purporting to be about epistemological beliefs about science in medicine and healthcare, but with few studies underpinning the research in theoretical models of personal epistemological development. Few studies also take multi-qualitative methodological approaches (such as with case study design) to provide deep and rich description of the complexity of the institutional settings and therefore of the multitude of factors within an institution that may have influencing factors on epistemological belief development. Most study designs use self-assessment questionnaires or ‘pen and paper’ data and as commented upon earlier in this chapter such an approach to data collection may hinder participant authentic experiential reflective thinking.

2.8. Summary Of The Chapter

Research has been published on medical student and graduate personal epistemologies regarding scientific theory bases in medicine and there is a separate body of literature regarding epistemological frameworks of knowledge development from educational and psychological perspectives. My research will extend beyond the individual epistemological perspectives to include curriculum factors affecting personal epistemological development and consideration of the impact of socio-cultural factors. There is a lack of current research regarding the epistemological development of scientific knowledge and how medical students view the nature of science and the role of science in medicine at key transition points within their medical training. This PhD aims to redress this particular void, which makes the research unique. By making explicit the perceived beliefs about the nature of scientific knowledge and its methods as applied to medical practice it is hoped to assist curriculum design regarding knowledge understanding; to support medical students to understand the inherent complexity and uncertainty of scientific theory that underpins medicine, that will eventually translate to aiding judgement making in complex and uncertain clinical environments.

Chapter 3: Methodology

3.1. Introduction To The Chapter

The overall objectives of the project are to deepen a theoretical understanding of how medical students view science and scientific evidence as it applies to medicine, by exploring how this understanding relates to their views about the nature of science. To achieve the project objectives, research questions were formed and the methodological design of the project is structured, to recap, by these research questions.

- What are medical students' beliefs and understanding about the nature of scientific knowledge as applied to medicine?
- What curriculum factors appear to facilitate or inhibit medical students' epistemological development, at key transitions?

Each methodological choice with which to explore the research questions brings implied epistemological theories to the project design and is both influenced by and influences developing research questions and objectives as a project progresses and takes shape (Carter & Little, 2007). The overall methodology is qualitative social research using a case study at the University of Exeter incorporating multiple views from participants.

The design of the case study involved four distinct phases. The first element involved analysis of policy and curriculum documents with a focus on epistemology using critical discourse analysis. The second element involved observation of learning episodes involving medical students and clinical / academic staff; the third was analysis of the personal epistemologies of medical students and front line educators through carefully facilitated discussions. Potential transferability of any findings was then tested in a fourth phase through discussion with two other UK medical schools. This allowed scrutiny of the study research methods and reaction to the findings.

3.2. Case Study Theoretical Methodological Approach

In this case study, the aim was to carry out a detailed exploration into the undergraduate medical student curriculum at one medical school in order to present an in-depth and naturalistic representative account of BMBS medical students' views and experiences of science and scientific evidence as it applies to medicine. Using a range of qualitative methods in one case study design was intended to provide deep and rich insights into medical students' experiences and provide a nuanced view of the research. The resource constraints dictated by a full-time PhD programme (three years), and the fact that this was personal research, not the work of a team, meant a choice was made to carry out the research at one medical school to avoid compromising on richness and depth of the data collection, likely to be watered down and more superficial if the study were to take place over several medical school institutions.

It has been stated that single cases allow researchers to investigate phenomena to provide rich description and understanding (Walsham, 1995) of complex systems. In this case the complex system under scrutiny was medical student epistemological viewpoints about sciences in medicine and the nature of scientific belief. In order to achieve in-depth knowledge of the research questions it was necessary to frame the study by situating both the context of the study (UEMS) and myself as the researcher.

3.2.1. Situating The Research

Situating the research makes clear what is being investigated. A useful way of looking at this is through activity theory, which can be used to provide an explanation of the various constituents of the research that is taking place. The case study in this thesis adopts socio-cultural theoretical approaches, which is at the root of activity theory. I am not embedding activity theory specifically as the primary methodological approach for this thesis, however. Activity theory is simply used to present the "situated contextualization," to "yield a richer and more realistic picture" of the case study (Engeström, 1995, p.396).

Activity theory is a framework for understanding human activities within their social, cultural and historical contexts. Kain and Wardle (2011, p.1) describe activity theory as something which "gives us a helpful lens for understanding how people in different communities carry out their activities", helping the researcher to see possibilities in their data, and to “expand” learning. Activity theory helps the researcher to identify relationships between the elements within the activity, how it is that the elements interact, influence one another or cause tensions or conflict in the goals of the activity. In this thesis the use of activity theory will identify the activity (the research questions) within a given context (at UEMS) and indicate how the relational elements are constructed. Activity theory has been used by other researchers in the fields of medicine and education, such as by Engeström (2010) to examine complex systems in healthcare, complexity in medical faculty teaching practice (Bleakley, 2010) and by Ajjawi & Bearman (2012) to explore social aspects of educational practice in medicine.

Figure A is a diagrammatic representation of activity theory, adapted from Kain and Wardle’s (2011) diagram of the structure of an activity system. The points of the triangle represent the different categories of the activity. Each element interacts; the synergies and contradictions amongst them define the activity that is the focus of my case study research (the research questions). There may be contradictions within any of the categories (for example, subjects’ priorities may not match their preferred ways of working), and between categories (for example, the tools available may not align with the preferred ways of working of the subjects, or the objectives of the system). Contradictions may be seen as points for growth. The components of activity theory triangle with respect to the current study are:

- **Tools:** These represent the physical objects, concepts and systems of symbols, such as language, that people use to accomplish the activity. In this thesis the tools are represented by curricula documents (Phase 1) and learning episodes (Phase 2).
- **Subjects:** These are the people engaged in the activity, who are the focus of a study on the activity. These are the medical students in Years One and Three and faculty staff (Phases 2 and 3), and includes the attitudes, personal histories, identities, priorities, preferred ways of working, interests etc. of the people involved in the activity.
- **Community:** This is the people and groups whose knowledge, interests, stakes, and goals shape the activity. They may be close to the activity (e.g.

policy makers in the University which hosts the medical school) or distant from it e.g. bodies such as the GMC or the UK Government Department of Health (DoH), or include the general ethos of current political trends relating to medicine and scientific research or attitudes of the general population to medicine in the UK. The community is represented in all 4 Phases of the project design.

- **Division of Labour:** This is how the work in the activity is divided among participants in the activity. It reflects the distribution of power in this system. The participants are Years One and Three medical students and faculty (Phases 2 and 3).
- **Rules:** These are the explicit and implicit laws, codes, conventions, customs, and agreements that people adhere to while engaging in the activity, such as those written into policy and curricula documents. All four phases of the project design encompass the category of 'rules'.
- **Motives:** These are the purposes and reasons for the activity, linked to immediate and long-term goals of the activity. Motives are captured within all four of the project phases.

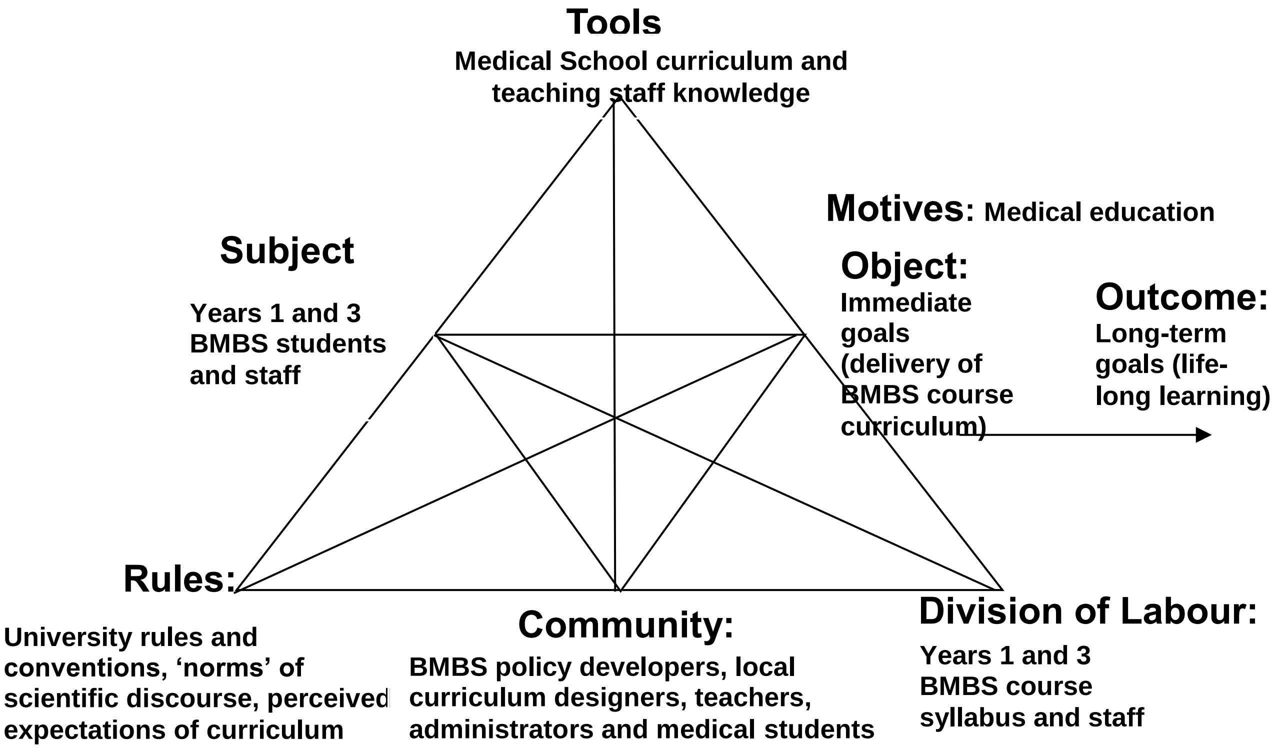


Figure A. Basic Structure Of An Activity

A key aspect of the theoretical design of this project is in adopting a constructionist viewpoint, in that the *participants* construct their understanding of their situation, and the identification of pattern/themes or trends from the research data which maps that understanding cannot be an exercise that is free from the *analysts'* constructed theories as a result of the interactions with participants (Lingard & Kennedy, 2010). My own background prior to PhD study was as a registered nurse with experience working in the NHS, charity and private sector. After ceasing clinical nursing in 2003 I spent fourteen years working for a non-governmental body as a regulator of health and social care services. Through my work in regulation and in attending numerous safeguarding conferences, in partnership with local authorities I became sensitive to power inequalities of 'looked after' individuals, be it in care homes, hospitals or people in receipt of care packages at their own homes. I was acutely aware of when people's care needs were discussed that these meetings took place amongst 'professionals' who discussed written reports about the needs of individuals, frequently citing the view of the professional on how a person's health needs should be managed. The people who were the subject of the meetings were usually significant in their absence; disempowered and voiceless. In 2009 I completed a MSc in Social Research Methods writing a dissertation on the patient voice in social care regulation using Foucauldian discourse analysis, providing prior background theoretical resources to the design of this PhD. Prichard et al (2004) remind us that it is not only the researcher's intellectual stance that readers of research deserve to be aware of but also an explanation of how the researcher had positioned themself to be able to carry out the research; both the qualification and qualities they possess that bring trustworthiness to the research design. My experiences and career choices leave me with a curiosity to explore relationships and inequalities in health care organisation systems. My professional career in health set me up as well suited to conduct research into medical education and provided authority and authenticity when interviewing medical students and faculty members at the medical school because I shared 'language' of clinical medical scenarios and health care organisational institution systems. My academic background is in the humanities and social research methods. The combination of these two strands gave me a well-rounded perspective in health care for a project that takes a qualitative perspective at medical education. I ally my epistemological standpoints with social and constructionist understandings of the world based on shared assumptions about reality; this implies that there are degrees of relativism within knowledge constructs. It can also mean that the exercise of power plays an essential role in the development of social discourses, that mould ‘norms’ of thinking and acting, and therefore my research viewpoint is a critical stance, looking for the influences of dominant and dissonant discourses. Accepting a relativist stance also does not mean that one accepts all points of view as having equal merit, that anything goes or indeed that fence sitting is a natural position. What the position does accept, however, is that there are a range of valid and useful methods and approaches towards exploring research questions and that as a researcher one can be open to exploring findings as negotiable constructs.

3.2.2. Case Study Setting

The history of undergraduate medical education at the University of Exeter Medical School began with the formation of the Peninsula Medical School (PMS), established in 2000 in partnership with the University of Exeter, Plymouth University and the NHS in the region. In 2007 a School of Dentistry opened, to create Peninsula College of Medicine and Dentistry (PCMD). In 2013 the partnership with Plymouth University ended and the University of Exeter Medical School (UEMS) was formed with its first medical students starting in September of 2013. Throughout this time the Royal Devon and Exeter NHS Foundation Trust provided hospital-based learning environments for medical students at its acute and non-acute locations as one of the hospital sites.

In this project the Year Three medical student participants were from the last cohort of PCMD and Year One medical student participants were from UEMS. The faculty and curriculum for the BMBS course was largely the same across both medical schools during the time of this project. At the medical schools, students applying from college for the BMBS programme are required to achieve A*AA - AAA at GCE A Level (or equivalent), to include chemistry and either biology or physics. Biology must be achieved at a minimum of Grade C at AS level if not studied at A level (UCAS search tool, Medicine, 2013). (In the UK, except Scotland, a GCSE is a qualification in a specific subject typically taken by school students aged 14–16, at a level below A level. An A level is a qualification in a specific subject typically taken by school students aged 16–18, at a level above GCSE. Students typically need three A level qualifications to enter university). To apply to medical school students are expected to have a strong background in the natural sciences.

The BMBS course design at the medical school involved early patient contact. This took place from term one, of year one onwards, gradually extending in length at the course progressed. At the medical school there was an emphasis on learning in small groups. Year One medical students experienced small group learning in problem based learning (PBL) tutorial groups, amongst other formats. In PBL there were 12 case units in Year One, running over two weeks for each case unit. There was six hours of PBL per case unit. The aims of PBL in medicine curricula have been defined as to help students to construct an extensive and flexible knowledge base, become effective collaborators, develop effective problem-solving skills, become intrinsically motivated to learn, and develop self-directed learning (SDL) skills (Loyens et al, 2008). In the PBL groups containing eight medical students, clinical cases are presented and themes emerging from the case are researched by medical students with a PBL tutor, who is part of the University faculty, facilitating and guiding sessions. Case themes are structured under the following headings;

- Bio-medical sciences
- Psychological sciences
- Social sciences
- Population health and healthcare improvement
- Integration of Medical Science and Professional Medical Practice

PBL tutors were supplied with information outlining the methodology of PBL with the aims of fostering the skills of SDL. The overall aim within PBL groups was to support medical students to “construct, integrate and contextualize their learning both conceptually and collaboratively” (Neve et al, 2012). This was achieved through exploring the case and thinking about ideas and concepts from the issues within the case. Tutors guided medical students in activating prior knowledge and identifying learning outcomes/questions for self-study, including discussion as a group to resources they could use to address their issues, particularly how the other elements of the curriculum could help them. The aim was to achieve SDL through seeking out knowledge and working to ensure that students understand and can explain it; including its relevance to the context of the case that is being studied. Medical students share the results of SDL in the next PBL session, including obtaining feedback and evaluation of their SDL from the group and tutor.

In addition to PBL, first and third year students attend lectures, small group learning in the medical school life sciences resource centre (LSRC) and clinical skills workshops. Clinical placements start in Year One, term one of the course, increasing in duration over Years One and Two. By Year Three the majority of the structured timetable was clinical placements. Year Three students did not have tutor led PBL sessions but continued to learn through other small group approaches.

Within the medical school all undergraduates sat termly medical knowledge (AMK) progress tests four times per year as one of the key assessments. The progress test, delivered in a multiple-choice question format (UEMS BMBS curriculum 2017; on-line), had design aims to assess long-term and functional knowledge, rather than detailed and easily forgotten ‘facts’ (Wade et al, 2012).

3.2.3. Case Study Criticisms And Response

A case study is defined as a detailed examination of one example (Flyvbjerg, 2006). This approach is sometimes critiqued, and as such criticism is that knowledge from one single example cannot be generalised to global groups. However, this is not the aim of the case study design of this project. Its aims are to contribute rich insights into the research questions and provide specifics of implications from knowledge gained by carrying out the case study. By describing the case study context in depth, these insights may be transferrable to other educational medical school establishments in which those involved can make a judgement about how closely their own situation matches that of the case study and therefore to what extent the research insights could be relevant or re-interpreted to inform their thinking and/or practice.

A second critique of case study research is a criticism often directed to qualitative research designs; namely that inbuilt bias causes problems for claims about verification of the research. In particular, case studies may tend to confirm the researcher's preconceived notions due to the researchers' subjective and arbitrary judgement being indulged in the immersive approach design of a case study.

During the data collection I keep a reflective journal about participant involvement and observation of learning episodes and how this impacted upon the project design. The journal was intended to provide deliberate self-reflection opportunities about difficulties encountered during the research, for example with participant recruitment, and alternative research design ideas and solutions reached in discussion with the project supervisors. This journal use was also intended to highlight my own biases and preconceived assumptions impacting upon the project deign, data collection and analysis. To illustrate, by being open regarding my nursing background and professional identity on health and social care regulation, including acute hospitals and primary care settings. This permits others reviewing the research to understand influences that may have impacted upon, for example, how interviews were conducted, should other researchers intend to design similar studies.

Qualitative research does not make claim to be an objective method of research. The subjective nature of qualitative research is its strength in providing the researcher with insights to their own reactions as data are obtained. This may lead to changes in their viewpoints regarding emergent themes and engenders a flexible approach to seek out unusual or atypical responses from participants in order to gain both breadth and depth in the sample data.

On the challenge of bias in case study research Flyvbjerg (ibid) concludes:

> *"The case study contains no greater bias toward verification of the researcher's preconceived notions than other methods of inquiry. On the contrary, experience indicates that the case study contains a greater bias toward falsification of preconceived notions than toward verification." (p237).*

On Flyvbjerg's observation it could be commented that this project design with a critical stance seeks to expose taken for granted 'norms' that have become part of intuitive discursive norms or curriculum practice. A strength of the method of case study is that is asks the researcher to reflect upon their developing skills and epistemological standpoints as a researcher as the project progresses in response to feedback from participants, which one may argue liberates the researcher from a dogmatic approach.

3.2.4. Design Phases Of The Case Study

The case study design was a four phase approach;

Phase 1:

Phase 1 involved a critical discourse analysis (CDA) of key policy and curricula documents from a Foucauldian methodological approach. Through the analysis of key policy and curriculum documents (tools, rules, motives and community within the activity), the CDA considered what were the implied or explicit dominant discourses regarding science, scientific methods and evidence based research within the undergraduate medical curriculum.

Phase 2:

Phase 2 was observation of learning episodes from the timetabled curriculum of those medical students taking part in the research. This phase captures the subject, community, tools, division of labour, rules and motives within the activity. Observation of learning episodes shed light on the epistemological messages delivered by the taught curriculum. The observations were intended to inform participant task groups/interviews, and were thus aligned to the approach of Eraut (2004) who wrote of using observations to 'ground' the interviews in real life. By observing learning episodes I was able to gain insight to learning experiences from the medical students' perspective and to reflect upon these learning episodes to assist me in the creation of appropriate relevant topics for the semi-structured interviews, which could be based on real and recent learning episodes and on what had been said or implied about science in medicine. One aim of this activity was to explore mismatches between the official curriculum in terms of the 'script' from official textbooks and recommended e-resources and the personal epistemologies about scientific knowledge as voiced by teaching staff, particularly in relation to the notion of medical uncertainty. 'Mismatches' could be a curriculum factor serving to send confusing and mixed messages to medical students indicating ‘constructive misalignment’, meaning that students have to construct learning for themselves (Biggs, 2003) and thus potentially impacting upon medical students’ epistemological development.

Phase 3:

Phase 3 was the recruitment of medical student and medical school teaching staff participants for the in depth discussion through task groups and interviews. This phase encompasses subject, community, division of labour, rules and motives of the activity. Task group sessions with Year One medical students took place exploring beliefs about scientific knowledge in medicine though a card sorting exercise and discussion around the prioritising of cards. Task groups were used to inform topic guides for semi-structured interviews with medical students and faculty, which followed the task group sessions. Semi-structured individual interviews then took place. These were with a subset of Year One medical students from the task groups to explore the research questions further on the themes that emerged from the task groups; with Year Three medical students using the same topic interview guide; and with faculty teaching staff, about their beliefs about scientific knowledge and the teaching curriculum.

Phase 4:

Phase 4 was presentations of the case study preliminary findings to lead medical educators at other UK medical schools, for comment upon the extent to which they thought the findings could be transferred to other UK medical schools. This final phase represents the community, rules and motives within the activity.

Phase	Timescale	Comments
Phase 1: Critical discourse analysis (CDA) of key policy and curricula texts.	Sept 2013 – Sept 2014	Any revisions or updates of key texts were considered after these timescales.
Phase 2: Observation of learning episodes (OLEs).	Sept 2014 – June 2015	Observation of learning episodes took place during the academic year of 2014/2015 concurrently with participant task groups and semi-structured interviews.
Phase 3: Task groups/interviews with Year One and Year Three medical students and faculty participants.	• Year One medical student task groups (Oct – Dec 2014). • Year One medical student interviews (Jan 2015 – Feb 2015). • Year Three medical student interviews (Nov 2014 – March 2015). • Teaching staff interviews (Feb 2015 – Oct 2015).	The timing of the participant recruitment, task groups and semi-structured interviews was dictated by the school academic year between September and June. Recruitment of medical student participants started in the first few weeks of the autumn term of 2014/2015.
Phase 4: Presenting the tentative case study findings to other UK medical schools.	Interviews (March and April 2016).	Interviews with lead academics at 2 UK medical schools with similar curricular structure to that at UEMS.

Table 3. Project Timeline

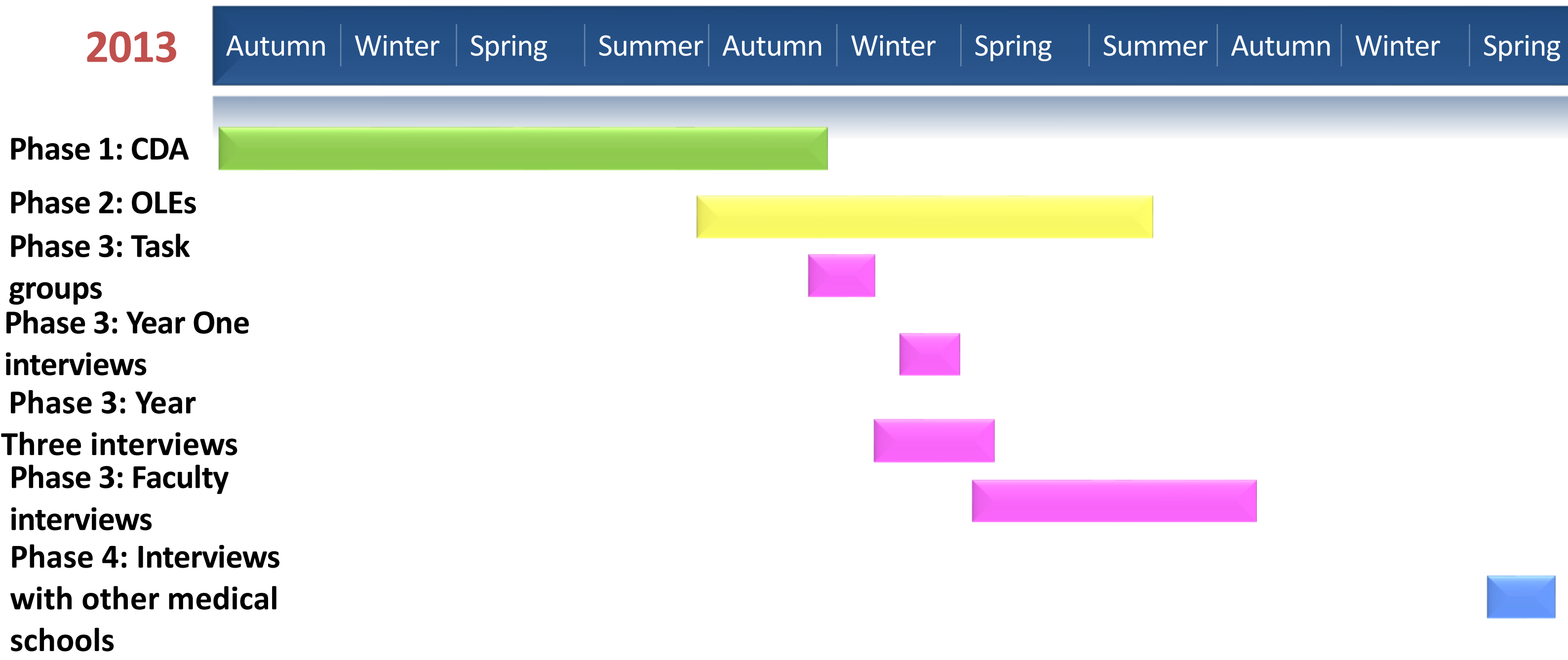


Figure B. Project Phases Showing Overlapping Of Timelines

Thematic identification and coding of task group sessions and interviews through interpretivist analysis of the transcripts of digital recordings of sessions took place after the completion of each constituent element, i.e. following completion of task groups and then following completion of interviews by participant group. The analysis took an interpretivist approach, which explores meaning within a data set. This interpretivist approach was shaped through the lenses of Foucauldian critical discourse analysis and psychological models of personal epistemological beliefs.

I will now set out the methodological approaches of the four phases of the project in more detail.

3.3. Phase 1. Critical Discourse Analysis Methodology: Introduction

This phase involved literature based analysis of key policy and curricular texts. Completion of the critical discourse analysis exercise was an important first phase in the research. It established the context of discourses in medical education about appropriate scientific content and approaches to studying science in undergraduate medical education within UK curricula documents. Completion of this first phase of the research set the scene for the following project phases involving curriculum observation, participant task group exercises and semi-structured participant interviews. The discourse analysis was intended to indicate the degree of alignment between statements or implied beliefs about science within the national regulator's guidance documents and the University's local curriculum.

The Critical Discourse Analysis (CDA) considered the contested medical student curriculum in terms of content by exploring assumptions, inconsistencies or disputes from key curriculum documents, for example, those from the GMC and the University of Exeter Medical School, starting with the key document *Tomorrow's Doctors* 2009 (TD09). The critical discourse analysis probed underlying assumptions of policy documents exploring formal statements and assumptions about science and scientific content intended for inclusion within the medical student curriculum. CDA is a qualitative methodology that employs the close analysis of texts to reveal influence, including intellectual authority and structures employed by institutions to reproduce dominance (Fairclough, 2003a). CDA can reveal bias or weighting assigned to subject matters, for example, within the curriculum documents.

Researchers that study discourses created within institutions are interested both in significant words and concepts in institution key policy documents. In this PhD the themes critically explored were the construct of implied or explicit dominant discourses regarding science, scientific methods and evidence based research within the undergraduate medical curriculum. Phillips et al (2004) claim within institutions it is texts which describe, communicate and influence actions creating a discourse of social actions. The authors argue "it is primarily through texts that information about action is widely distributed and comes to influence the actions of others" (p.635) and the "institutions are constituted by the structured collections of texts that exist in a particular field and that produce the social categories and norms that shape the understandings and behaviours of actors" (p.638). This implies great influence is imparted at the point of the choice of texts with which to represent a curriculum with the influence of human agency in reaching the decision.

Inevitably discourse analysts (and arguably all researchers) offer interpretations which are interpretative and partial. Ferrara (1995) argues this is the case for all research activities, whether quasi-experimental, historical or qualitative. What discourse analyses are able to do, however, is show how power, influence and knowledge are socially constructed through representation. A 'lexical label' becomes a social fact, an accepted truth. Some discourses become more powerful and go unquestioned. For example, that medicine is scientific, factual and progressive, despite comment that a clearer understanding of science, its strengths and limitations is beneficial to the development of critical thinking within the medical profession (Maudsley & Stivens, 2000).

The overall research aims of this PhD were to explore medical students' beliefs about the nature of knowledge, particularly scientific knowledge at key transition points in their education. The purpose of the analysis of the texts, which applied a Foucauldian approach to CDA, was to explore formal statements and assumptions about science and scientific content intended for inclusion within the UK medical student curriculum. These statements and assumptions reflect the context in which undergraduate medical education is happening and shapes the kind of curricula decisions that are possible. Specifically the aim of the CDA was to reveal implied or explicit discourses regarding science, scientific method and scientific research and the values attributed to such epistemological positions. The chosen texts for inclusion in the study were international and national key policy and local University curriculum documents in the undergraduate medical curriculum. Foucauldian approaches were a good fit for the discourse analysis; Foucault's own interests included medical education (Hodges et al, 2014) and the medical professions' claims of scientific objectivity as a way of knowing (Johnston, 2014).

3.3.1. Critical Discourse Analysis As A Methodological Choice

CDA methodology, incorporating Foucauldian approaches, was chosen as a suitable approach to consider the structuring of scientific approaches and scientific research topics within the medical education field and medical school curriculum and any bias or weighting assigned to subject matters.

Discourse analyses have proved an effective approach with health research questions that explore complex phenomena and meaning making (Hodges et al, 2008). Other documentary research techniques, such as discursive psychology and content analysis were also considered. Although discursive psychology has routes within discourse analysis and shares assumptions about language construction, linguistic analysis and ideological critique with critical discourse analysis (Kress & Hodge, 1979), discursive psychologies typically focus upon face to face encounters and identity making through self-narration and self-descriptive talk (Gergen & Gergen, 2003). Such a micro-analysis approach to human meaning making is typically less used for the analysis of texts such as manuscripts like curriculum documents as primary sources of evidence. Content analysis is concerned with looking closely at themes within published literature including latent or manifest meaning (Graneheim & Lundman, 2003). However, commonly the themes of content analysis pertain to robustness of findings and reliability of research processes. For my analysis, it is the uniqueness of the engagement of a Foucauldian approach to critical discourse analysis and its concern with matters of power, that led to the decision to apply this method to the analysis of curriculum, where the powerful influence the many. Therefore Foucauldian discourse analysis is highly relevant to the research question.

3.3.2. What Are Discourse Analyses?

Discourse analysis is a term for broad and varied qualitative methodological approaches to the analysis of written, spoken or signed language use (Wetherell et al, 2003). Foucauldian discourse analysis is one approach to discourse analysis. Qualitative researchers are interested in explorations of situated social, relational and context-specific heuristic experiences (Lingard & Kennedy, 2010). Discourse analyses examine in detail official or published texts. They are methodologically qualitative, as they are interpretative and explanatory, concerned with exposing patterns or themes within language used as a conventional linguistic system. A range of discursive methods are underpinned by different, and at times, contesting epistemological assumptions about theory and knowledge (Kuper et al, 2008). Discourse analysis methods challenge the assumption that language, whether spoken, signed or written, is neutral and transparent and therefore value free. Additionally the contexts of texts are relevant in terms of power and influence. For example within an undergraduate medical school curriculum, which may be fluid and subject to changes in personnel driving curriculum changes, there will likely be curricular interest in trends with regard to population health studies and concerns affecting NHS treatment priorities as well as contesting discourses within the curriculum regarding the value of differing scientific disciplines and epistemologies on the nature of scientific knowledge. There are contesting discourses within medicine regarding the value of differing scientific disciplines and which should be included in the undergraduate curriculum. Van Dijk (2008) argues to ignore context in research leads to "trivial descriptions that seriously under-analyze discourse, as it is deeply embedded in social and political life (p.ix)."

Discourse analysis research has by tradition been interested in policy making processes, power, institutions and/or institutional practices, their culture and context (Fairclough, 2003b. Van Dijk, 1993). Discourse analyses have been useful methods for researching attitudes, epistemologies and identity formations and in developing theories about such phenomena. As such, discursive analyses have similar research interests with ethnographic studies, which engage directly with people and their experiences within groups, cultures and societies, either by direct observation of events or through the reading and examination of documents and records (Hammersley & Atkinson, 2006). However, applying a Foucauldian approach within a case study of an undergraduate curriculum in a UK medical school is a novel and original study design.

3.3.3. Critical Discourse Analysis And Social Action

CDA theorists like Van Dijk (1993) view positions of power within groups as relatively stable. Using CDA to make visible accents of power or influence within the medical education curriculum through a critical paradigm is a way of highlighting inequalities, so that change can be affected.

For Van Dijk (ibid) the explicit commitment to political causes is another interpretation of the 'critical' in critical discourse analysis. The application of critique and criticism to political and social relations is called for because of the positioning of group membership categorisation and the impact upon each groups' associated ability, or lack of ability, to affect societal influence and social change. Foucault, however, believed that research findings can have political applications and influence political policy (Foucault 1973, 1977 and 2012), but that it was not the role of the researcher to agitate politically. This echoes a view by Schlegoff (1997) that academic findings ought to be divorced from active politics in order to not risk devaluing academic research.

On the relationship between knowledge and power, unlike many critical discourse analysts, Michel Foucault's works implied power creation and application was not linear or necessarily top down but encompassed all levels of social life and circulated both within and between groups (Fraser, 1981. Ford, 2003). The Foucauldian epistemological position that power circulates and is can be contested, subverted and challenged at both local and macro-levels (Hall, 2003). In other words, people are not necessarily always powerless and opportunities arise to challenge the power status quo, create new regimes of influence and affect new paradigms and theoretical standpoints on social issues. Thus, for the Foucauldian scholar, overt political agitation is less of matter of ethical concern than for CDA purists, because Foucauldians believe mechanisms exist for power and influence to ebb and flow between institutions and groups. However, to suggest that Foucauldian research is apolitical I suggest is naïve, given the constructionist beliefs concerning identity, knowledge and power and the historical perspective of discourses being socially constructed over time.

The aims of this PhD is to not shy away from exposing inequalities or underrepresented areas of science in medicine within the curriculum and to recognise if there is poor understanding of the nature of science in relation to medicine in medical student epistemologies. The aim is to provide curriculum decision makers with evidence to take forward in curriculum design to assist in the educational development of medical students on their journey to becoming doctors who acknowledge and embrace limits in knowledge when thinking about medicine.

3.3.4. Foucauldian Approaches To Discourse Analysis

Foucauldian CDA challenges the assumption that language, whether spoken, signed or written, is neutral and transparent and therefore value free. For a social theorist like Foucault the contexts of texts are relevant in terms of revealing power and influence. Foucauldians believe discourse is enmeshed in the material world and within an epistemic regime. Discursive meanings are not fixed because all discourse is socially constructed. On the topic of science and scientific knowledge, the contexts are current theories about scientific knowledge and the apparatus for defining technical language, such as governmental, educational and health care systems involved in managing the agenda where the discourses of science are played out. To illustrate, an undergraduate medical school curriculum may be fluid and subject to changes depending upon the academic interests and involvement of faculty personnel driving curriculum changes. In this respect there are useful and corresponding theoretical approaches when applying Foucauldian analysis in a context that has been defined by activity theory (see section 3.2.1). There are also contesting discourses within the wider medical academia regarding the value of differing scientific disciplines and which should be included in the undergraduate curriculum. In addition, the curriculum is influenced by wider Governmental policy concerns with regard to population health studies and concerns affecting NHS treatment priorities.

Foucault was interested in histories of institutions, social change and modes of representation. One of the topics that interested Foucault was the development of medicine and medical education in Western Europe. Foucault's research methods took a historical perspective. He argued that from the eighteenth century onwards the development of "medicine into the general functioning of scientific discourse and knowledge" arose through medicine's socialisation into an establishment of "collective, social and urban medicine" (in Faubion ed, 1994, p.150). In other words, over time, the developing discourses about which sciences became prominent in the development of medical knowledge tended to rise out of the management of health care concerns affecting large populations. Because of population growth, medicine necessarily become increasingly organised and subject to bureaucratic and state management (Foucault, 1973). For Foucault the status of good academic research was when research is made meaningful by situating it within a wider historical context (Hall, 1990). Therefore in this case study the research is set in a point in time and specifically about the University of Exeter medical school but the wider historical context is the development of undergraduate medical education in the UK.

Discourse analysts are interested both in significant words and concepts in institution key policy documents. The Foucauldian methods critically explores themes in the construct of implied or explicit dominant discourses regarding science, scientific methods and evidence based research within undergraduate medical curricula. In this project, the focus is a case study at the University of Exeter Medical School and the professional regulating body licensing the medical school and the registration of doctors (the GMC). Phillips et al (2004) claim within institutions it is texts which describe, communicate and influence actions creating a discourse of social actions. The authors argue that the “institutions are constituted by the structured collections of texts that exist in a particular field and that produce the social categories and norms that shape the understandings and behaviours of actors” (p.638). This implies great influence is imparted at the point of choice of texts with which to represent a curriculum with the influence of human agency in reaching the decision.

It has been argued by Brosnan (2013), that in recent times medical education researchers “have a tendency” to pay lip service to theory or conceptual frameworks underpinning chosen methodologies. She argues researchers fall foul of making a conceptual error if they fail to acknowledge medical education research is not theory and value free, but situated and driven by beliefs and assumptions about the nature of reality and society. For Foucault discourses are systems of representation where meaning is produced within a social, cultural and historical context. The Foucauldian scholar has an intellectual curiosity to how discourse subjectivity, or the hidden curriculum develops within educational settings. This methodology assumes truth is relative to the discursive linguistic tussle of the moment and that truth has a cultural frame of reference, thus implying historically contingent verisimilitudes. This, in turn, implies the Foucauldian theorists’ findings are relative and open to reinterpretation, as boundaries shift as a consequence and new approaches emerge. Nonetheless, even within a Foucauldian methodology researchers have to make choices and decisions about inclusion and exclusion, what needs to be examined and explored? For example, how representative chosen texts are of the concerns within the research questions, or any limits to explorations of additional research questions revealed by the reading of texts taking into account practical considerations such as access to human resources and time limitations. On the topic of science and scientific knowledge, the contexts are current theories about scientific knowledge and the apparatus for defining technical language, such as governmental, educational and health care systems involved in managing the agenda where the discourses of science are played out. The following diagram summarises the constituent elements of discourse analysis, CDA and Foucauldian CDA.

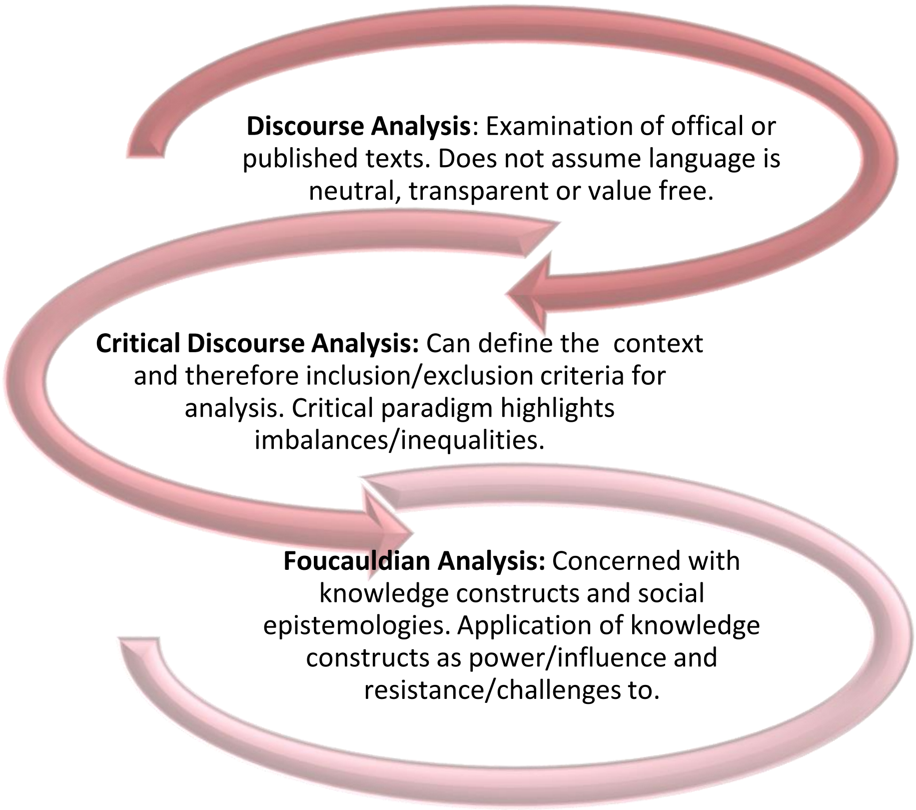


Figure C. Elements Of Foucauldian Critical Discourse Analysis

3.3.5. CDA Literature Search Strategy

The search strategy for texts to analyse started with academic peer reviewed literature on undergraduate curricula to help me identify key curriculum policy texts cited in the academic literature. I then searched UK curriculum policy documents (grey literature). I then widened the search out to key international curricula guidance documents before narrowing to the University medical school texts (key policy documents such as medical school prospectus, information sent to new medical school students in year one of the course, term one/year one study resources from the University medical school intranet and terms one and two/year three study resources). The CDA literature searches took place between Sept 2013 – Sept 2014. However, I repeated searches throughout the three years of the PhD programme to search for current and new publications for the peer reviewed literature and UK/international curriculum policy texts, such as the GMC '*Promoting excellence: standards for medical education and training'* (2015), which are standards in medical education at both undergraduate and post-graduate level and came into force on 1 January 2016.

I printed off copies of all texts and annotated notes directly onto the texts, providing a summary of the key themes and interesting aspects of the arguments made in each text. Each text was read at least twice and fresh notes were made when returning to texts, to record how my perspective may have changed as I gained deeper insights into the debates. I then collated each sub-set of texts, for example, UK curriculum policy documents in separate ring binders with a sheet of paper summarising the themes across all texts in the sub-sets as a summary in the front of the folder. This helped me maintain an overview of the different aspects included in this CDA, which was broad in its search. In contrast to the narrower approach of Whitehead in her thesis on the discourse of '*The Good Doctor In Medical Education'* (2011), where her searches were limited to debates within medical education and in particular from the medical education intellectual community publishing in the US based *Academic Medicine* journal, my approach was wider and included discourse analysis stemming from education that was not limited to medical education. This was because of my prior experience at Masters degree level and familiarity with debates in discourse analysis stemming from a more general social research community and from benefitting from the expertise from my PhD supervisors whose academic backgrounds came from the fields of clinical science and science education. My primary supervisor's previous research includes a study of medical student's personal epistemologies and my second supervisor has published research in the fields of science education research and professional education. This breadth of background, expertise and professional interests meant that I had the tools to be able to cite my theoretical knowledge across and not only within research disciplines.

Texts were accessed through the General Medical Council (GMC) web-site, e-library search engines, physical library resources or via the University of Exeter intranet. Electronic data bases used were; Health Sciences On-Line, JSTOR, Google Scholar, Athens, EBSCO E-journals, ISI Web of Science, Sage Encyclopaedia of Qualitative research, SAGE Open and Wiley Open Access. E-searches included the following search words as above and assorted combinations of: General Medical Council, undergraduate medical education curriculum, history of medicine. Separate searches were made to develop methodological understanding using search key words that included; critical discourse analysis, Foucault, research and science in medical education, qualitative research methods and science in medicine. The earliest date restriction for curriculum document searches was from 1858, the date of the *Medical Act*, which established a regulatory body for medicine in the UK (this eventually became the General Medical Council). However, for the academic peer reviewed literature this was set from 1910, the publication date of the *Flexner Report*.

3.3.6. Inclusion And Exclusion Criteria Of Texts For The Critical Discourse Analysis

I started my CDA literature searches with peer reviewed academic journal articles on the topic of undergraduate medical education in the UK. All potentially relevant academic peer-reviewed articles found were read for potential inclusion in the study. I also hand searched the medical school library journals in education and medical education for relevant articles. I used references cited in articles and links sent to me by my supervisors and peers to other books and articles that may be relevant to my research questions. Through reading abstracts articles were either included or excluded in terms of relevance to the research questions and project methodological design. Although the search design was not exhaustive it is unlikely that any central resources would have been missed.

Following searches for academic articles this led me to the key UK curricula policy guidance document *Tomorrow's Doctors* 2009 (TD09), as it was cited in academic journals as the key policy guidance document for current undergraduate medical education in the UK. TD09 published by the regulator for medical education in the UK, the GMC, and was concerned with curriculum statements, standards and outcomes within the undergraduate medical curriculum. TD09 was the central point for searches and inclusion of text criteria from earlier versions of *Tomorrow's Doctors* (1993, 2003) for analysis in order to draw conclusions about temporal trends. Curricula publications that were cited by *Tomorrow's Doctors* or were mapped to intended learning outcomes of *Tomorrow's Doctors* were included in the analysis. This was limited to policies written in English for countries where the language was primarily English. The inclusion criteria policy guidance documents were limited to those from professional regulatory bodies from the UK and North America. North America was included as medical education in the United States and Canada were the focus of the pioneering 1910 *Flexner Report,* which had influence on curricula design in the UK. From North America I chose CANMeds (2005), the curricula policy document in Canada, as this document can be shown to share a number of approaches to current UK based competency based curriculum design, as featured in TD2009 and CanMEDS roles "have been adopted and worldwide, such that they now represent one of the world's most widely used competency frameworks" (Kuper et al, 2017, p.159).

Literature type	**Inclusion Criteria**	**Examples**	**Number of Texts Included**
'Grey' literature focusing on UK and international undergraduate medical education.	Relevance to the research questions. Published since the 1858 Medical Act. Written in English. Pertaining to UK medical schools (can cross ref. intended learning outcomes). Narrow inclusion criteria.	Policy documents in the UK and North America published via regulators of medicine: E.g., Tomorrow's Doctors, Flexner Reports, CANMeds, The Scottish Doctor.	10
Academic peer-reviewed literature	Relevance to the research questions. Published since the 1910 Flexner report. Written in English. Wide inclusion criteria, narrowed down by abstract reading.	Searched using databases/search terms: E.g., articles on medical education curriculum design, science in medical education, discourse analysis in social sciences and medical education; wide inclusion criteria. Hand searching key journals.	430
UEMS/PCMD curriculum documents	Relevance to the research questions. Relevant to Year One Year Three medical students. Current documents. Narrow inclusion criteria.	E.g., medical school brochure, information for new medical students, study unit information.	18

Table 4. Summary Of Texts Included In The Critical Discourse Analysis At Different Levels.

3.3.7. Foucauldian Analysis Methodological Approach

Foucauldian method is concerned with discursive patterns and weighting including what is not said, how concepts are defined or absence of definition of key terms. For this research the key terms were 'science', 'scientific methods', 'research', 'outcomes' and 'competencies' in medical education. This is because one way to enact power is to control the context – the curriculum concerning the basic science foundations of medical education argument. There is no clearly formulated Foucauldian method for analysing talk and texts (Edwards, 2005). Instead it is a lens used in this research to explore specific knowledge and truth claims and counter discourses. The method is particularly suited to case study research (Hodges et al, 2008) within social institutions. Foucault's method of analysis was called 'genealogy.' This was not a prescriptive method but referred to an approach to study discourse to reveal power and knowledge constructs by tracing the history and development of knowledges and their power effects to reveal the status of such in the current day.

Adapting Carabine's guide to doing Foucauldian genealogical discourse analysis (Carabine, 2003) the first steps for the analysis of key curriculum and policy texts concerned context and outlined the background to the issue and contextualisation of the material in the power/knowledge networks of the period. The next steps were to identify themes and categories in the discourse. Inter-relationships between discourses were then identified and the discursive strategies that are used were identified. Absences and counter discourses were commented upon and then the effects of the discourses were discussed. My analysis steps were;

- Reading data and annotation of texts. Repeated re-reading of key texts.
- Identification of key words, categories and themes in a historical context relating to research questions (defining science in medicine, defining scientific knowledge in medicine, approaches to carrying out scientific research in medicine, bias of topics for inclusion on the undergraduate curricula) .
- Looking for absences or counter-discourses in the themes.
- Identifying the possible effects of policy document discourse on science in medicine on the medical school curriculum through note making.

- Presenting the findings by theme in historical context. Identifying epistemological assumptions underlying themes (Table 6). Mapping of statements about scientific knowledge in medicine found in curricula documents to theories of epistemological development (see Figure H) on a new chart that I devised; based on existing epistemological theory (Figure D).
- Acknowledging and reflecting upon limitations of the research, data and resources in a research diary at the time when the limitations presented themselves.

3.4. Phase 2. Observation Of Learning Episodes.

Prior to commencing qualitative data collection in the 2014/2015 autumn term I based myself in the medical school in an open plan office setting amongst UEMS faculty. Through informal conversations with faculty I was able to gain an outline understanding of how the BMBS curriculum was structured and the names of key faculty members delivering teaching and small group learning to medical students. Schatzman & Strauss (1973) suggest that through initial visits to an observational setting or institution the qualitative researcher will get to know whom to sample for the purpose of the study. Similarly, Pritchard et al (2004), advocate that researchers develop a reflexive understanding of the context in which they find themselves. They suggest that this practice “not only enriches the research practice, it also provides much of the ‘between the lines’ knowledge that can lead to successful research outcomes” (p.213).

The decision to sample and observe learning episodes from the taught BMBS curriculum as experienced by Year One and Year Three medical students was in order to ground the task group exercise and subsequent interviews in real situations and specific activities (Eraut, ibid). It is argued (Lederman et al, 1998, Guerra-Ramos, 2012) that participants do not effectively convey what they know about the nature of science in response to abstract, context-free questions. Therefore during the task groups and subsequent individual interviews discussions were guided to experiences from the medical school curriculum and experiences of learning sciences at colleges prior to coming to University (interview guides for medical students are detailed in Appendices 1 and 2).

In the Foucauldian methodological approach, insight into meaning generated in institutional settings is most effectively established thought direct observation of how institutions function (Prichard, ibid), in addition to critical analysis of policies and key texts of the curriculum.

For this study it was important that medical students and faculty participants became accustomed to seeing me as a PhD researcher around the medical school, attending lectures and small group learning sessions. This was to establish a familiarity with me as researcher to promote trust in the task groups and interviews that I was to conduct. It also gave potential participants the means and opportunities to speak with me informally about the project and for them to consider the benefits or disadvantages in joining the project in terms of their freely given consent to participate.

The learning episodes that I chose to observe were selected over a wide enough range for me to gain insights about how science and the nature of scientific evidence in medicine was presented, and talked about, by faculty and medical students in such sessions. The learning episodes were thus chosen to represent a range of conceptual approaches to science in medicine during the autumn 2014/2015 term from the Year One and Year Three BMBS curriculum. For example, to gain depth and breadth in the appreciation of the curriculum, the choice in the Year One timetable was to follow two case units taught during this term (case units are based around problem-based learning (PBL) sessions and clinical placements, bio-medical science tutorials, clinical skills training and lectures). The observation of learning episodes took place at the same time that task groups were conducted so that I could steer task group discussions to current real curriculum learning. This included observing lectures and sitting in to observe small group learning sessions, called problem based learning (PBL). In PBL episodes, fictional medical cases, and the science behind the medicine, is discussed between medical students in the presence of a PBL facilitator. Each case unit held three PBL sessions with up to eight medical students and a PBL facilitator. In the first session a fictional case on a topic, e.g. ‘Infancy’, was interrogated to extrapolate themes for learning, such as bio-medical questions, anatomy and physiology, psychology and social considerations. The following week involved two PBL sessions where medical students brought their learning on the themes from the case unit to the group for discussion and to evaluate their learning. Case scenarios therefore took place over two week cycles. To identify which teaching sessions I would attend, I held two meetings with course leads to discuss strategies to cover teaching sessions that had primarily bio-medical, anatomy/physiology slants, those covering social science/humanities in medicine concerns and sessions introducing evidence to medicine. It was also decided to attend sessions delivered by faculty with primarily clinical positions as well as those with primarily teaching or research positions to hear how the approach to scientific methods was presented and if individuals differed in their emphasis.

Year Three PCMD medical students had a timetable that was less University based involving predominantly clinical placements. Each student had an individual timetable following a clinical scenario pathway with one ‘academic day’ per week. I attended plenary lectures in the autumn term of 2014 delivered on clinical themes in the pathways the Year Three students would experience in their clinical placements. In addition I attended some clinical teaching sessions held at the medical school to hear medical students talking about their learning experiences.

By observing learning episodes in the 2014/2015 autumn term when medical students were participating in task groups and/or interviews this meant I could shape the research activities so that the medical students would be able to recall real and recent learning episodes during the transition period into the new academic year and reflect upon this. Mays & Pope (1995) claim that using observational methods in health settings are “particularly well suited” as they overcome the researcher hearing, from participants, hypothetical accounts and therefore inauthentic reflections on thought and actions during discussions with the researcher. For the Foucauldian researcher applying context to the meaning of events defines and situates the research and therefore is more likely to deliver believable descriptions of the phenomena being observed. This is because practical knowledge of institutional settings (the educational setting of the medical school) by researcher immersion provides valuable understandings on how organisations work and supplements theoretical knowledge gained from participant accounts of how the institutional setting works gained through the interview techniques.

3.4.1. Phase 2. Data Collection

During observations of learning episodes, such as lectures and classroom based teaching sessions within the timetabled BMBS undergraduate curriculum, I made written notes focusing on what the lecturers depicted about their topic in terms of personal epistemologies on the nature of science, research strategies/methods and the complexity or uncertainty of the nature of knowledge in the topics. Where learning episodes, such as lectures, were recorded by the University and posted upon medical school intranets, I accessed such recordings though the medical schools intranet portals. As a research student enrolled at the medical school I was able to attend lectures at the school. However, on each occasion I approached the lecturer in advance via my supervisor based at UEMS, as a courtesy, to ask their permission to sit in on the session and take notes as an observation of learning episode. It was explained that this was for data gathering for the PhD project and the study aims were given. For other observations, such as PBL, permission was sought from the programme year one lead and individual PBL tutors in advance, including explanation the nature of the study. I took notes only during small group teaching sessions; I did not audio record or video the small group teaching sessions. I looked at recordings of lectures available on the medical school intranet. Hand written notes were written up in word documents with anonymised names of BMBS students and PBL facilitators.

3.5. Phase 3. Participants

The participants for Phase 3 of the study were First and Third Year BMBS medical students in the academic year 2014/2015, and faculty based at UEMS. The two medical student cohorts were chosen since they were undergoing significant transitions in their learning journeys and therefore might provide useful insights into the research questions. Year One BMBS medical students were included as they were undergoing a transition from secondary education to a university medical school setting. Information in the 2013 University of Exeter medical school prospectus advises “in years 1 and 2 you’ll learn the core scientific foundations of medicine.” Year Three medical students begin the journey of transitioning from being based primarily in a university to a healthcare setting, learning to become “patient centred” and developing “problem solving skills.” This was another key transition for medical students on the course programme. It was anticipated that these transitions would be particularly interesting in terms of epistemological development as they signified fundamental shifts from being concerned primarily with thinking about the role of science in medicine to applying scientific knowledge in the practicing of medicine and making patient diagnoses and treatment plans. Hence, the approach to selecting and sampling medical students was purposeful, based upon the selection of medical students who could provide best insights into the research questions around acquisition of knowledge or development of knowledge about science and scientific evidence as it relates to the study of medicine.

Faculty participants were individuals who taught on the medical programme. The aim of individual discussions with faculty teaching staff was to explore their beliefs about scientific knowledge and the teaching curriculum, which would shape the informal and hidden curriculum. Individual semi-structured interviews were chosen, rather than focus groups, because it was thought that focus groups would prove difficult to arrange with busy teaching staff schedules and the topic could be seen as sensitive in a group dynamic. Faculty participants were categorised into the following groups: ‘ very close faculty’ (mostly PhD scholars and with >0.5 FTE involved with teaching of the BMBS curriculum), ‘close faculty’ (mostly medically qualified clinicians with a UEMS contract and who worked between 0.2 and 0.5 FTE for the medical school on the teaching of the BMBS programme) and ‘distant faculty;’ medically qualified clinicians who received medical students on clinical placements but had chosen not (or not had the opportunity) to be more involved in the University education curriculum.

3.5.1. Phase 3. Sampling Strategy

A sampling strategy and sampling framework was developed to explain and justify the choices made in recruiting participants to Phase 3. The sampling strategy was intended to set boundaries for whom, why and what was sampled and how this fits with the research questions being explored. In this qualitative case study intended participants were able to reflect upon their learning experiences and had to be willing to share their personal views with the researcher. A clear sampling strategy was intended to assist any future replication of the project by other researchers. By establishing a sampling framework and explaining how this developed, criticism of rigour of the project design is less likely to be encountered (Kitson et al, 1982).

Sampling approaches in qualitative research differ according to the needs of individual studies. For example, sampling approaches may be research question driven and purposeful, designed according to theoretical concerns, open or opportunistic sampling, total population sampling, maximum variation sampling, typical case or variant sampling or changing to include some combination of the above as data are gathered and new research questions are created. Sampling approaches and strategies are shaped and subject to time and resources the researcher has available to them and approaches can be restricted by resources placed upon participants by the researcher (Schatzman & Strauss, 1973). The overall strategy used for this project is purposeful, driven by the research questions.

A purposeful sampling approach used in qualitative studies differs from random statistically driven approaches commonly seen in quantitative or experimental methods research within health research typical of research in bio-medicine (Mays & Pope, ibid). In qualitative research sampling is seldom statistically based and therefore P-value probabilistic figures cannot be used. P-values are used in random sampling to test hypotheses and quantify the likelihood of the data that were collected being achieved if the null hypothesis were true. This is a key tool in establishing the generalisability of the findings to the population of which the research sample is representative. Qualitative research approaches using purposeful sampling do not use statistical calculations to make statements about generalisability to a population. In contrast, they deliberately and purposefully seek out information-rich cases in a particular group or setting to fit the study (Coyne 1997). Purposeful sampling does not aim to generalise to a whole population, rather to indicate common links or categories shared between participants, such as the setting and educational experiences. Their responses or feedback may influence further purposeful sampling to seek out new participants with atypical experiences. The rationale behind modifying a sampling strategy during the research is so that a range of variations, breadth and depth of experiences from participants relevant to the research questions are sampled and explored. The use of purposefully sampled learning episodes has the aim of providing the best design for addressing the research questions and is an approach to research design that has been effectively used to previously explore exploration of secondary student's understanding of the nature of science (Solomon, 1996).

Variability from participant involvement in expressing their personal views is expected and actively sought out in qualitative research in order to reflect the uniqueness of human experiences (Field & Morse, 1996). In this research atypical participant responses links to the Foucauldian approach weaving through the overall project design, which is interested in dissonant or minority voices within discourses, representing alternative views or challenges to cultural norms within institutional settings. Unlike quantitative research, qualitative researchers are interested in the range of participants' experiences and richness of informants' information, rather than the average experience. Quantitative researchers use outlying data to describe boundaries or may choose to exclude such outliers from their analysis. In qualitative research individual responses may not be completely representative of a group but all experiences are considered valid and atypical views are important to include in the research findings, as they may indicate emergent categories for further exploration.

One criticism of qualitative research and purposeful sampling is that the methods used tend to generate large amounts of subjective detailed information in a limited number of settings and therefore lacks generalisability (Mays & Pope, op. cit.1995). However, it is the participant subjective constructed perceptions and meanings on the research questions that qualitative research actively seeks out. Kirk & Miller (1986) describe qualitative research as "a particular tradition in social science that fundamentally depends upon watching people in their own territory and interacting with them in their own language, on their own terms" (p.216). The quantitative perspective on consistency and generalisability is based on the assumption a single unchanging and replicable reality for the purpose of a controlled experimental environment. Qualitative research, however, seeks spontaneity in responses and assumes multiple constructed realities in the descriptive responses from participants. Krefting (1991) explains the art of qualitative research in learning *from* informants rather than controlling *for* them (p.216). In this way additional research questions may be generated during qualitative research due to the subjective nature of participant interaction and dialogue with the researcher in contrast to a methodological design of testing a hypothesis more often used in quantitative research.

When defining research rigour in qualitative research issues of reliability, external validity and replication are replaced, in Agar's terms, with credibility, accuracy of representation and authority of the writer (Agar, 1986). Therefore this sampling strategy aimed to generate rich information, be driven by the research questions and be relevant to the conceptual methodological framework underpinning the whole research project.

The initial sampling for Years One and Three medical students was open sampling from the entirety of the Year One and Year Three cohorts, on a volunteer basis. This strategy reflected the research design that no medical students were excluded from the study based on, for example, gender, age, ethnicity or home country of study prior to entering the medical school. Coyne (1997) describes open sampling as "sampling those persons, places, situations that will provide the greatest opportunity to gather the most relevant data about the phenomenon under investigation" (op. cit. p.626). The initial purposeful, then open sampling was intended to include the broadest possible representation of each cohort.

Following task group sessions a selection of 12 Year One medical students were invited to attend an individual semi-structured interview to further explore the research questions. Year One medical students invited for interview were sampled purposefully, chosen primarily upon their contribution to the task groups.

The aim of individual interviews was intended to explore individual voices more deeply, including those of dissent from group norms presented in the task groups (see Mays & Pope, 1995). Those Year One medical students invited to attend the interviews were purposefully targeted to reflect diverse medical student groups with particular characteristics. For example, school leavers with direct entry into medical school, medical students entering UEMS as graduates, medical students with maths/science A levels only, medical students with humanities A levels /healthcare backgrounds and international students. This is because it was anticipated that there would be potential differences in how these groups viewed and spoke about the nature of science and evidence as regards to science in medicine. I aimed to select a good mix of males and female students to ensure a wide diversity sample. I identified the entry route and background study characteristics of each medical student by making notes following the participant sessions to collate demographic information. Further Year Three medical students were also targeted through 'snowballing', where one medical student suggested another, where there were under-represented groups of medical students e.g. international students.

The sampling approach for inviting faculty members was based on a targeted and purposeful strategy. Unlike the initial open sampling approach with medical students sharing a common identity of all being enrolled on the BMBS undergraduate course, not all faculty taught on the BMBS course, nor were they necessarily employed to spend a significant amount of their working week in teaching activity. Therefore purposefully sampled faculty at UEMS were those faculty employed by the University of Exeter in the education and scholarship academic job family, and clinicians who were either employed by the University of Exeter or NHS, who either taught on the programme or received medical students on placements. These faculty were considered to be key to forming the informal and hidden curriculum within the formal BMBS curriculum at the medical school, such as through role modelling or models of partnership with the NHS beyond the medical school. In a qualitative study the richness of evidence matters. Therefore I wanted to interview medical school teaching staff from a range of health disciplines and specialities (both non-clinical academic and clinical academic). I aimed to interview a minimum of 12 faculty, with a range of teaching commitments with the medical school.

The selective and purposeful sampling for interviews reflected a research aim at this stage of looking *for* data rather than looking *at* data to fulfil the Foucauldian methodological stance of searching for unusual points of view and experiences and dissonant voices.

3.5.2. Reflection And Adaptations To The Methodological Approach

The research adopts an iterative methodological approach, where there was reflection on initial findings, for example after the initial two task groups. This led to decisions being made regarding which demographic group of participants, if any, were missing or underrepresented in the study for targeted purposeful sampling. Reflecting on the data from participant task group sessions and initial medical student and faculty interviews also both refined and supplemented the questions presented to task groups and interviewees in future sessions. These revisions sought clarification on themes emerging in the discussions.

3.5.3. Phase 3. Recruitment

Medical student participants entering Year One of the BMBS programme in 2014/2015 and Year Three of the BMBS programme in 2014/2015 were recruited. Approximately 130 Year One medical students enrolled at UEMS in 2014/2015 and approximately 200 Year Three medical students were enrolled at PCMD at this time. These two groups were the medical students approached to take part in the project. In all 25 Year One and 14 Year Three medical students took part in the project.

Those medical students who participated included these groups;

- medical students who entered medical school at age 18 with the usual three sciences and/or maths A level,
- medical students who took at least a year out to gain work experience before entering medical school,
- mature medical students who were accepted for entry to medical school via the Graduate Medical School Admission Test (GAMSAT) or equivalent,
- international medical students,
- medical students who studied social sciences or arts/humanities at A level in addition to traditional sciences.

All volunteers were asked to complete a demographics monitoring sheet for analysis when the task groups or semi-structured interviews commenced. This was to monitor which groups were already interviewed, to ensure diversity of participants was happening as intended.

Group discussions in the form of task groups encouraged participation from those reluctant to be interviewed on their own. It was thought this might be an issue particularly with Year One medical students entering medical school fresh from college at the age of 18. For Year Three medical students and faculty this was felt to be less problematic, as these groups would be more likely to have more confidence and experience in participating in research interviews at medical schools. Therefore task groups were limited to Year One medical student participants only.

It was decided to not recruit Year One medical students based on existing groups, such as problem based learning (PBL) groups. This was because such groups may have established group dynamics and pecking orders, which could be replicated in the task group, affecting status and vocalisation in the task groups. There was also a risk that extracting medical students from pre-arranged allocated groups could still lead to under-representation according to demographics groups within cohorts. In terms of ethical considerations it could be viewed that sampling by pre-allocated groups could introduce an aspect of coercion into participant selection, should medical students fell pressured into joining the project when others in the group indicated a willingness to take part.

For faculty participants, the group was heterogeneous (e.g. those who were primarily University lecturers or primarily practising doctors), so I attempted to recruit a significant proportion of each group. I aimed to recruit approximately 12 staff volunteers to speak with in a semi-structured interview. The numbers were restricted to those people interested, and had time available. As with medical students it was aimed for both females and male faculty staff to be included in the interviews.

Year One medical students were approached to take part in the research by making a short announcement at the start of teaching sessions, asking medical students to provide their contact details and by giving students printed information about the study (see Appendix 4 for medical student information sheet). When presenting the project to medical students as a group, for example before a lecture commenced as part of the recruitment strategy, it was said that all medical students were welcome to take part and could phone/email me for an informal chat before choosing to take part. It was also said to Year One medical students that they could opt to be part of a task group or just 1:1 interview, or both, if this was their preference, to maximise numbers willing to be part of the study. After this I also advertised the study via the University internal email to Year One and Year Three medical student cohorts via the faculty leads for the medical student year groups. Medical students could choose to ignore and delete the email.

Year Three medical students were recruited in the same way as Year One medical students: I briefly presented the aims of the research study in lecture sessions and asked medical students to leave their contact details if they were interested in hearing more about the project and/or taking part.

To recruit faculty participants to the project the approach was personal introduction and an internal email to faculty identified as key shapers of the curriculum because of their time spent in delivering learning episodes. The email included an information sheet about the project and the purpose of the interviews (see Appendix 5 for faculty information sheet).

3.5.4. Phase 3. Data Collection For Task Groups

Twenty five Year One medical students took part in task groups exploring individual beliefs about science and experiences of learning about science during the first term of the academic year 2014 – 2015.

Task groups and interviews took place at the University of Exeter Medical School. Interviews were conducted by me, and were recorded using a voice recorder. Task groups and interviews were transcribed verbatim by a professional transcribing service. The transcriber had experience in transcribing qualitative research and had experience with working on previous research projects at the medical school. In being employed on behalf of the medical school for the transcription service the professional transcriber signed a confidentiality agreement with the medical school purchasing office.

The task group sessions took place with between 3 – 8 medical students and lasted one hour. There were five task group sessions in total.

I used a range of cards with words relevant to the study topic to stimulate group debate. Card games have been used in this way in teaching settings since the 1970s, and in their teaching experiences Cobern and Loving (1998) attested that the cards served as a good ‘ice breaker’ during an introduction to a topic and that, during the course of the conversation stimulated from choosing cards, participants naturally reflected upon their own beliefs about science and how these beliefs did or did not coincide with what others in the group believed. The task groups with open-ended questions were intended to allow participants to prioritise the issues of importance about science and scientific knowledge in medicine in their own words. The task groups also provided an opportunity to explore the research questions broadly, in order to make subsequent choices for purposeful selective sampling of medical students for semi-structured interviews in the following phase of the project, where deeper questioning of the epistemological reasoning behind the statements medical students had voiced about science and the nature of evidence in medicine was discussed. The rationale for using task groups where cards with descriptive words were laid out for medical students and asking them to consider and pick those cards they thought were particularly relevant to science in medicine was twofold. Firstly to stimulate debate should conversations naturally end and secondly to focus medical students on the research question should the discussion ‘drift.’ When a medical student picked up a card they were asked to defend why the descriptive word ‘spoke’ to them. This made the medical student reflect upon their choices of word and their personal perspective. The cards were spread out in front of the task group participants. The purpose of this task was to have a discussion about students’ individual beliefs about scientific knowledge and the nature of evidence and was driven by the key research question;

- What are medical students’ beliefs and understanding about the nature of scientific knowledge as applied to medicine?

Each card contained one word and included the word’s intended continuum ‘opposite pole.’ The cards were identical in each task group. The words used were adapted from Water-Adams’ (2006) bi-polar semantic differential. (Although this piece of research took place in a primary school setting, the approach to exploring epistemological viewpoints on the nature of scientific enquiry was not inappropriate for use in a higher educational setting). The bi-polar semantic differential is a continuum scale of words with their semantic opposites intended to be used for assessing attributes that could be applied to science, its nature, the kind of knowledge science produces and where participants rated themselves along the continuum between the two word 'opposites.' The words are shown in Table 5 below:

• explanatory	• descriptive
• certain	• provisional
• sure	• tentative
• cohesive	• unconnected
• subjective	• objective
• verified	• unconfirmed
• public	• private
• imprecise	• precise
• discovered	• constructed
• changing	• unchanging

Table 5. Task Group Card Sort Descriptive Words.

Table adapted from Water-Adams' 2006 study in a Devon primary school involving primary school teacher's beliefs about science and the understanding of the nature of science and their practice.

I shortened and adapted Water-Adams' 2006 bi-polar semantic differential for descriptive attributes about the nature of science and scientific methods to fit my research question and manageability of a planned 45 minute task group. The card choosing exercise was designed and intended as a precise way of honing in on 'myths and fables' about the nature of science as discussed in Rubba, Horner and Smith (1981). Their research in one junior high school in the US revealed 30% of students taking science believed scientific research revealed incontrovertible absolute truths (dubbed the myth of absolute truth) and scientific theory, with constant testing and confirmation, eventually maturing into laws (nicknamed the laws-are-mature-theories fable).

It is argued (Lederman et al, 1998b. Guerra-Ramos, 2012) that participants do not effectively convey what they know about the nature of science in response to abstract, context-free questions. During the task groups and subsequent individual interviews I guided discussions to provide examples from experiences from the medical school curriculum and experiences of learning sciences at colleges prior to coming to University. Asking medical students to cite experienced examples of science teaching in real experiences follows in the tradition of Nott and Wellington (1995) and Solomon (1996) of probing scientific 'knowledge in action,' rather than 'academic knowledge.' In this way it was anticipated that participants would be less likely to regard the exercise as a 'test' of knowledge and feel under pressure to give the researcher answers the participants thought were 'correct.' The card choosing exercise provided a snapshot in time of Year One medical students' prioritising of terms used to describe science and the type of knowledge that science produces. Medical students were asked to justify their word choices. For example, I encouraged debate with medical students regarding their views about the nature of scientific knowledge, asking participants to describe what it means to apply a scientific method in medicine and how this differs from a non-scientific method. The medical students were asked to use examples of experienced learning episodes to ground the task group exercise (and subsequent interviews) in real situations and specific activities (Eraut, 2004). For example, the Year One term one case unit of 'Infancy' and the problem based scenario regarding measles, mumps and rubella immunisation (MMR) and claims about scientific 'truth'. If students indicated science was verified and sure, I used debate about the Wakefield research, covered in this unit, to ask medical students about validity in scientific research. (Andrew Wakefield is a doctor who in a 1998 research paper published in *The Lancet*, claimed a link between the administration of the measles, mumps and rubella (MMR) vaccine, and the appearance of autism and bowel disease. This led to a drop in the childhood uptake of MMR, and therefore immunity rates. After a UK broadsheet newspaper identified ethical concerns regarding conflicts of interests in the research funding on Wakefield's part and other researchers being unable to support the initial research findings, the GMC launched an investigation into Wakefield, who was eventually struck off the UK medical register. *The Lancet* retracted the research paper as fraudulent in 2010).

3.5.5. Phase 3. Data Collection For Semi-Structured Interviews

Following the task group sessions, emergent themes were identified to create semi-structured interview guides for the subsequent interviews with medical students and faculty members around personal beliefs about knowledge and knowing, and their perceptions of science and of evidence. The framework for the emergent themes was based on seeking to provide insights into epistemological development, key barriers and transition, and how medical students' epistemological development might be supported better. The semi-structured interview guides were developed around the following emergent key themes:

- What have been medical students' prior experiences of learning about sciences?
- What does it mean to be scientific?
- What is scientific about the approach to medicine?
- How do experiences of learning about sciences at school, college and prior to medical school entry differ from that experienced at the medical school?
- When and how are students introduced to concepts of complexity and uncertainty in medicine?
- To what extent do students struggle with concepts of complexity and uncertainty in medicine? (See Appendices 1 and 2 for medical student participant semi-structured interview guides and Appendix 3 for faculty participant semi-structured interview guide).

I interviewed 12 Year One medical students and the 14 Year Three medical students who volunteered to be interviewed. I interviewed 16 faculty (seven defined as 'very close faculty', who were mainly PhD scholars, six defined as 'close', who were medically qualified clinicians and three defined as ‘distant faculty’, who were medically qualified clinicians receiving medical students on clinical placements).

With faculty interviews I explored their perceptions of medical students’ tolerance of medical uncertainty, specifically in relation to the taught curriculum in terms their assessment of medical student expressed beliefs about the nature of science and scientific method. During interviews, faculty also expressed their own personal views about the nature of science and the nature of scientific evidence in medicine.

Semi-structured interview questions were informed by the topic guide and further refined as the interviews gathered momentum and with greater evidence gathered by the observation of learning episodes in the curriculum. This reflected an iterative aspect of the methodological design of the research through repeated analysis of how the research questions were being explored and refinement of interview questions to seek out further clarification or deeper exploration of interview questions that were perhaps perceived as difficult to answer.

3.5.6. Phase 3. Participant Data Analysis Methods: An Introduction

Analysis of task group discussions and semi-structured interviews involved two distinct phases: The first round was data-led, driven by the interview data content and emergent key issues and themes within, leading to inductive, reflexive analysis. A coding framework was developed and mapped for each participant group (Year One, Year Three, faculty) for this round of analysis.

The second round of analysis of the task group discussions and semi-structured interviews was theory-led, mapping the research questions to models of personal epistemological development. A coding framework for the second round of analysis was developed from these theories and mapped across all participant groups.

Each participant included in the research was assigned a unique identifier and all data were stored without identifying details (see Appendix 7 for an example of part of a participant transcript). A personal copy of the task group or interview transcript was offered to each participant.

3.5.7. Phase 3. Data Analysis 1st Round: 'Data-Led' Analysis

For the first round of data analysis, participant task group and interview data were arranged and refined by themes informed by the research questions. Thematic comparisons and findings of the data were emergent and iterative (Onwuegbuzie et al, 2012. Onwuegbuzie & Leech, 2007). I was mindful that when looking at a large quantity of qualitative data for interpretive and comparative purposes there was a risk of applying a blunt approach to identifying themes and categories to the opinions, experiences, attributes and thoughts expressed. In line with a Foucauldian approach atypical or absent views were noted.

To enhance rigour during analysis I included independent analysis of a subset of 4 of the 47 total transcripts by both my supervisors for the purposes of discussing our initial analysis of the emergent themes. We met face to face to discuss and negotiate our impressions of the data to develop a coding framework inductively.

I adopted the approach of listening to each transcript as an audio recording as I read the transcript, making notes and annotations on the transcript as I listened to the audio recording. I then wrote themes on a mind-map and used this to group the themes/sub-themes and subsequent sub-theme/sub-headings within. The refining of themes to produce a final coding framework went through 9 rounds of re-evaluation and revision.

By abstracting themes, defining them, refining and arranging themes I developed a framework, to enable the mapping to themes emerging from the data. I maintained a record of summary and illustrative data for each participant group, to facilitate further interpretation. From the data-led analysis I identified three key themes, which were developed into codes (See Appendix 8 for an example of a working document for data-led thematic analysis codes). I wrote on each transcript where I saw their comments aligning with the final coding framework, but also keeping an open mind and noting where participant comments did not fit the coding framework for 'dissonant voices'. I then used Word as a tool to map codes for each participant group (task groups, Year One medical student interviews, Year Three medical student interviews, faculty interviews). I copied and pasted from the individual transcripts sections of the data that had a fit to the themes as either sub-themes or sub-heading of the sub-themes to build up a map of participant responses arranged by theme. Where participant comments linked to more than one sub-theme or sub-heading their responses were recorded in every applicable sub-theme or sub-heading. I found the benefit of using Word was the ease and functionality provided of being able to see the whole document clearly, especially when printed off. This enabled me to be able to print and lay each document side by side on a surface to compare, further annotate write comments upon. I then combined the participant groups' coding frameworks into one overall data-led analysis document. I found it helpful having both the groups and overall Phase 3 participants' documents, for use in the subsequent 'theory-led' analysis, where analysis of epistemological development was set out by participant group and by already having mapped the emergent theme of 'nature of science' this assisted in the application of theories of epistemological development to this information in the subsequent round of data analysis, led by theories of epistemological development.

3.5.8. Phase 3. Data Analysis 2nd Round; 'Theory-Led' Analysis

Participant task group sessions and subsequent interviews with Years One and Three medical students and faculty were analysed using a framework, based on existing epistemological theory, to explore where individual participants might be placed on a four quadrant chart regarding individual beliefs about the nature of scientific knowledge in medicine.

I developed the four quadrant chart (Figure D), with the horizontal axis informed by Nott & Wellington (1995). In their paper about using critical incidents in the classroom to explore teachers' views of the nature of science, they used classroom experiments and recorded how teachers reacted when the experiments 'failed'. Part of the method of using critical incidents was to explore how teachers explained the reliability and replicability of practical experiments. Some of the findings showed several teachers had belief that 'failure' could be explained by perceived 'errors' in technical set up of the apparatus (conviction in the reliability of method), or justification of result 'rigging' to produce replicable results and therefore consistency of knowledge claims. These attributes indicated something about the nature of science as scientific activity divorced and isolated from or interrelated within social contexts and social concerns. I used these concepts of the nature of science as socially contingent or socially isolated to label a horizontal axis on my chart as a continuum from (socially isolated concepts) ‘discovered, universal facts’ to (socially contingent) ‘constructed and contextual models of knowledge’. My intersecting vertical axis on the chart concerned the status of truth claims in scientific thought; right versus wrong knowledge, uncertainty of knowledge and the legitimacy of differences of viewpoints. This axis development was informed by Schommer’s (1990) epistemological beliefs instrument, developed for research into college undergraduates’ beliefs about knowledge and King & Kitchner’s (1994) reflective judgement model of epistemological beliefs, developed in the research of college students regarding beliefs about certainty of knowledge. From their models I used the notion of certainty of knowledge as a continuum labelled ‘certain knowledge’ and ‘tentative knowledge’.

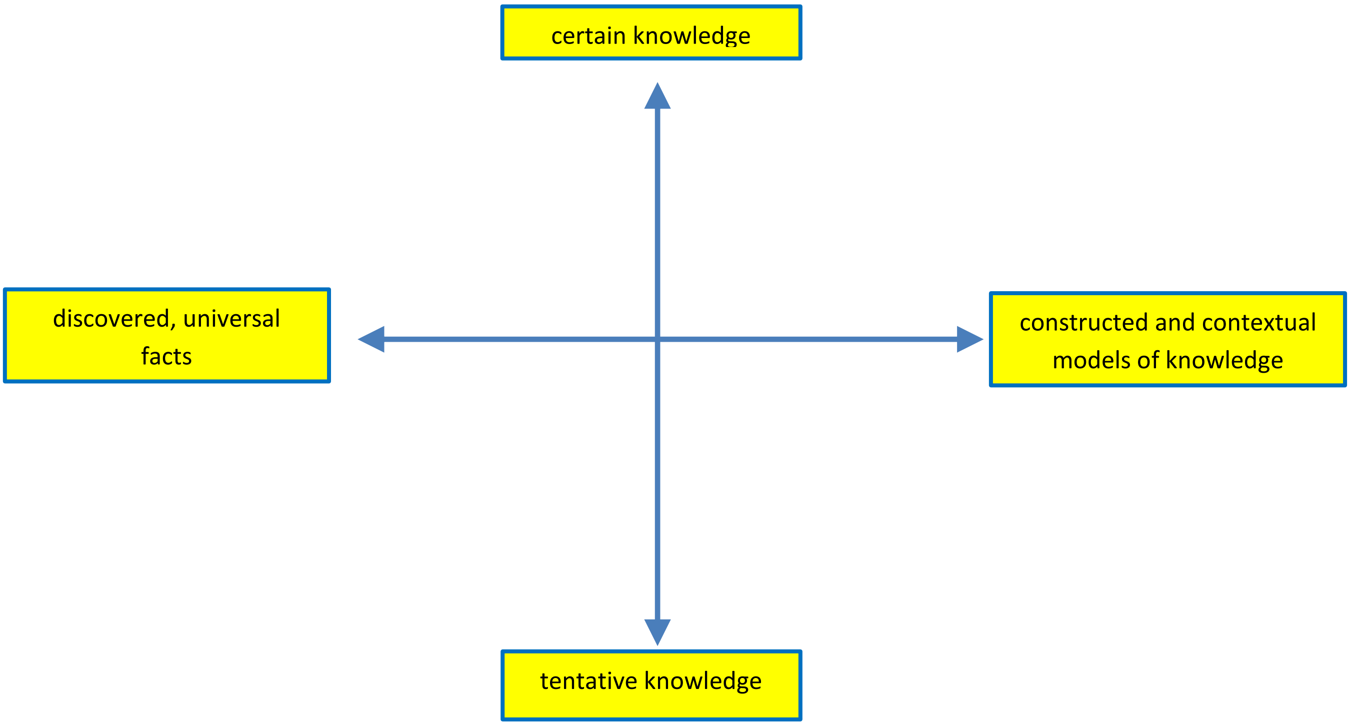


Figure D. Chart Developed To Map Participant Beliefs About The Nature Of Scientific Knowledge In Medicine.

Data were analysed thematically based on interview questions about the nature of science in medicine, leading to a conceptual model of epistemological development in medical students and faculty personal epistemological beliefs.

Where participants in groups were placed within a quadrant would be an indication of beliefs about the nature of scientific knowledge in medicine and conceptual models of personal epistemological development (see section 6.2 in Chapter 6 Theory-Led Participant Findings). The aim was to provide easily accessible visual representation of a complex dataset.

3.6. Phase 4. Mitigations Of A Single Site Case Study Design – Presentation Of Findings To Other Medical Schools

To have wider applications of any recommendations from the research, initial findings were presented to two other UK medical schools to explore how closely the findings translated to other settings, their contexts and undergraduate programmes. This was intended to see how individual and context-bound the findings from UEMS were likely to be. For example, did other medical educators think the findings rang true to them, or was this different from their experiences?

The responsibility for assessing the transferability of findings would lie with the other institutions approached to comment on the tentative research findings (Lincoln & Guba, 1985). The other medical schools would make the interpretation to whether my findings at UEMS rang true for their particular situation.

By seeking comment on the transferability of the project findings through purposeful sampling of UK medical schools the aim was to develop a strategy to establish trustworthiness and credibility of the research (see Krefting, 1991, p.217).

3.6.1. Phase 4. Participants

Two UK medical schools were approached, selected as those set up at or around the same time as the Peninsula Medical School in 2000, sharing a similar approach to curriculum design to that of PCMD and UEMS i.e. early clinical contact from the first year of study and an emphasis on small group learning, using PBL.

3.6.2. Phase 4. Recruitment

Recruitment took place via email personal introduction through my supervisor in the medical school. The email introduction included a brief summary of the project aims, methodological design and the purpose of the interview to present initial findings with the view of conducting an interview discussion to the applicability of any of the initial findings to their educational setting.

3.6.3. Phase 4. Data Collection

Data collection took place through a Skype interview, lasting approximately one hour and 15 minutes. Prior to the interview I had sent an email with an overview of my initial findings to the interviewees. The interview started with me recapping my initial findings for approximately 15 minutes, I then asked open questions using prompts sourced from their medical school curriculum structure to explore similarities and divergences in the other school’s curriculum and whether the interviews could see any resonance with what medical students and faculty had thought from my findings at Exeter. The interviews were recorded via a voice recorded, then transcribed, verbatim.

3.6.4. Phase 4. Data Analysis

Data from the two transcribed interviews were reviewed by listening to the audio recordings and reading the transcripts. Then I made notes of the responses to the similarities or divergences from my initial findings and the explanations to these interpretations by the participants.

3.7. Key Ethical Considerations

Ethical considerations constituted a fundamental role in the research design and execution. Ethical aspects of the methodology have been indicated in sections 3.2. - 3.6. and will now be grouped for a detailed portrayal of the considerations in one section.

The study was submitted for review to the Ethics Committee of the University of Exeter Medical School and approval was granted in October 2014 (see Appendix 6 for research ethics approval document).

Ethical considerations were formed using the key principles in the framework for research ethics published by the Economic and Social Research Council (2015). One key principle from this publication involves being explicit regarding any conflicts of interests or partiality of the research. Other key principles are; providing appropriate information about the project for participants so that valid and voluntary consent for participation can be given; respect for the anonymity of research participants; assessing risks and minimising potential harm of participants; and protecting participant personal data.

- Research Funding, Conflicts of Interests and Research Partiality

The research was funded by the University of Exeter Medical School. The study was based at the University of Exeter Medical School. The medical school was chosen on the basis that the research was funded by the University of Exeter Medical School and the researcher was based there, having access to resources and personnel. Although funded internally by the medical school I was not expected to make a contribution to the evaluation of the medical school or report to internal forums within the medical school. I also had joint supervision of my project between the Medical School and University's Graduate School of Education. In this way I felt that I had research distance from the medical school.

- Participant Information and Voluntary Consent

Medical students were able to make their own decisions about whether to participate in the research after receiving an information leaflet about the study and being offered the opportunity to discuss the implications of the study by contacting either myself or my supervisors. Written consent forms for participation in task groups and individual semi-structured interviews were completed when the task groups and interviews took place. Medical students were able to opt out of the study at any time without penalty by contacting me by email/text or by speaking to me in person. Faculty consented in a similar way to medical students and were able to withdraw from the project via the same means.

- Protecting Participant Anonymity

Interview recordings, transcripts and notes were stored securely in locked premises before being transcribed onto a password protected computer. All audio-taped qualitative data in task groups and interviews were anonymised by a professional transcribing service. Data were stored electronically and were password protected.

- Assessment of Harms

Task group sessions and semi-structured interviews with participants took place during the daytime at the University of Exeter Medical School, St Luke's campus, Exeter. Year Three PCMD medical students were based half a mile away at the Wonford hospital campus or at the medical school Cornwall campus site. Medical students were invited to have the semi-structured either at the St. Luke's campus or in a meeting room at the medical school building, not attached to the main hospital or clinical areas, to their preference. Meetings with participants took place convenient locations and times for participants. Medical students in Cornwall were offered the option of interview by phone.

It was considered unlikely that any medical students or teaching staff would be significantly distressed as a result of participating in the study because the subject matter was about conceptual belief systems. The study did not seek to elicit sensitive or confidential data. In addition, the purpose of task groups was to create a collaborative group dynamic that drew on the strengths of all participants with no one (including the task group facilitator – the PhD researcher) assuming the role of expert. If any concerns were raised by participants, either spontaneously or during the task groups and interviews relating to personal pastoral or welfare issues, it was agreed with the ethics committee that participants would be advised to raise the concerns with the pastoral tutor team at the medical school or their line manager.

- Protecting Personal Data.

All confidential data were held in accordance with the Data Protection Act. Data were held on a secure database on a password-protected computer supplied to the student by the University of Exeter. Access to data was restricted to me and my supervisors. Hard electronic recording and paper records were stored in a locked cabinet in my home office. All documentation will be retained for ten years.

3.8. Summary Of The Chapter

This chapter has detailed the methodological approaches adopted, the four phases of the case study design and ethical considerations of this study. The overall methodological approach is interpretative, which is informed by three strands of constructionist theory; critical theory from Foucauldian discourse analysis, socio-cultural theory in the form of activity theory and psychological theories of personal epistemological beliefs (EBs).

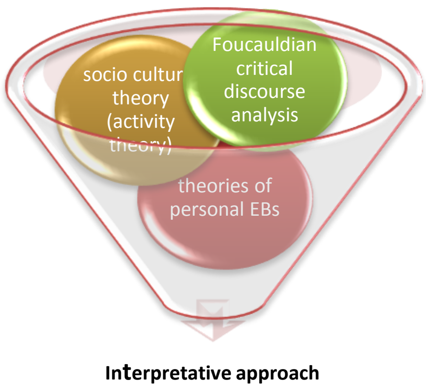


Figure E. Methodological Approaches Used To Inform The Case Study Design

In the next four chapters (Chapters 4 – 7) I will present findings from the case study design.

Chapter 4: Critical Discourse Analysis Findings

4.1. Introduction To The Chapter

This analysis of policy and curriculum documents within the undergraduate medical curriculum, considers what, if any, are the implied or explicit dominant discourses regarding science, scientific methods and evidence based research. The documents meeting the selection criteria for the discourse analysis (see methods chapter sections 3.3.5 – 3.3.6) were key curriculum and policy documents from the General Medical Council (GMC) starting from the publication of the first GMC *Tomorrow's Doctors: Recommendations on Undergraduate Medical Education* (1993), other policy documents from international undergraduate medical education regulatory bodies and curriculum documents produced by the medical school. This critical discourse analysis examined chronologically policy and curriculum documents, then identified epistemological assumptions underlying scientific discourses within the documents. The findings are presented in a summary table (Table 6) and statements about scientific knowledge in medicine found in curricula documents are represented in a figure (Figure H), devised from theories of epistemological development (see methods chapter section 3.5.8).

4.2. Medical Education, Scientific Discourse And Key Curriculum Documents

In medical education one way to enact power is to control the context for discourses about science and scientific research in medicine. At the top down level, or executive decision making position, the context is the regulator's policy statements and guidance documents for medical school curricula, informing the creation of individual medical school curricula documents. If top level curricula and policy statements set out the professional and institutional discourse within medicine as a 'scientific' discipline (Van Dijk, 2001), it is argued (Nesler et al, 1993) that these 'credible sources' of scholars, experts or professionals set the agenda for what is accepted as the discourse of medicine as a science and informed by scientific debate. In the UK, medical schools' curricula are regulated through the GMC. Prior to the 2015 publication of a joint undergraduate and postgraduate guidance curricula document entitled *Standards For Medical Education And Training,* the key GMC documents for the standards and outcomes of undergraduate medical education for 22 years had been *Tomorrow's Doctors*. There have been three versions to *Tomorrow's Doctors* since it was first published in 1993, with two revisions in 2003 and 2009. The first version of *Tomorrow's Doctors*, in 1993 cited influence from The Flexner reports of 1910 and 1912, and all versions of *Tomorrow's Doctors* have influenced revision of medical education curricula across the UK, in North America and Australia (Iobst, 2010). In *Tomorrow's Doctors 2009* there were three overarching intended outcomes for undergraduates. These were:

- The doctor as a scholar and a scientist
- The doctor as a practitioner
- The doctor as a professional

In the foreword of *Tomorrow's Doctors 2009*, it is stated that changes were made from previous editions, in response to concerns about scientific education and curriculum content. However, the document does not disclose what these concerns were, or who had raised them, when and why, and no further information regarding the document revision to the concerns has been published on the GMC website. The *doctor as a scholar and scientist* is the primary outcome in terms of exploring discourses concerning the formal curriculum in relation to scientific epistemologies because this outcome is concerned with the curricula requirements regarding the development of scientific medical knowledge.

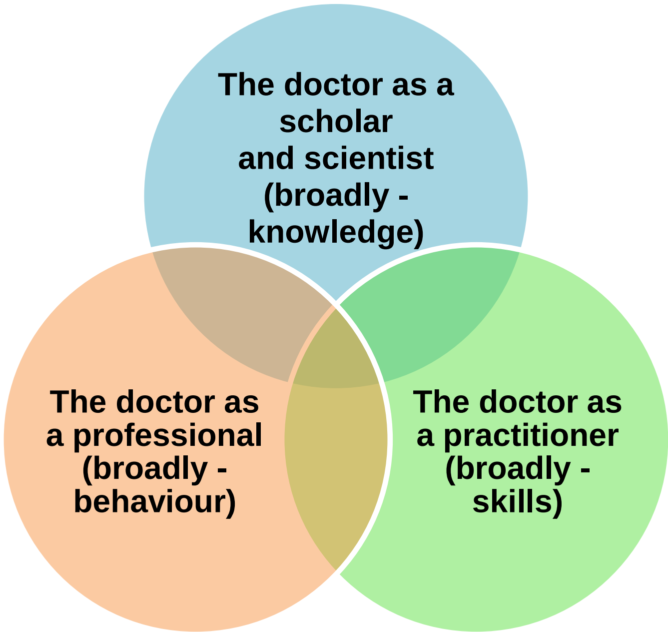


Figure F. Tomorrow's Doctors Outcomes

To achieve this outcome in *the doctor as a scholar and a scientist* medical schools are bestowed the task of ensuring students learn "basic and clinical sciences", and that medical students "link theory and practice" (p.47). Many schools aim to achieve this by providing study modules and supporting resources within the medical school undergraduate programme, educational institution policy documents, mission statements and documents and guidance notes for course topics. At UEMS these aspects of theoretical practice are linked to practical clinical experiences, for example in the form of simulated clinical scenarios with actors and early patient contact from term one of year one by placements with clinicians in hospitals and community healthcare settings.

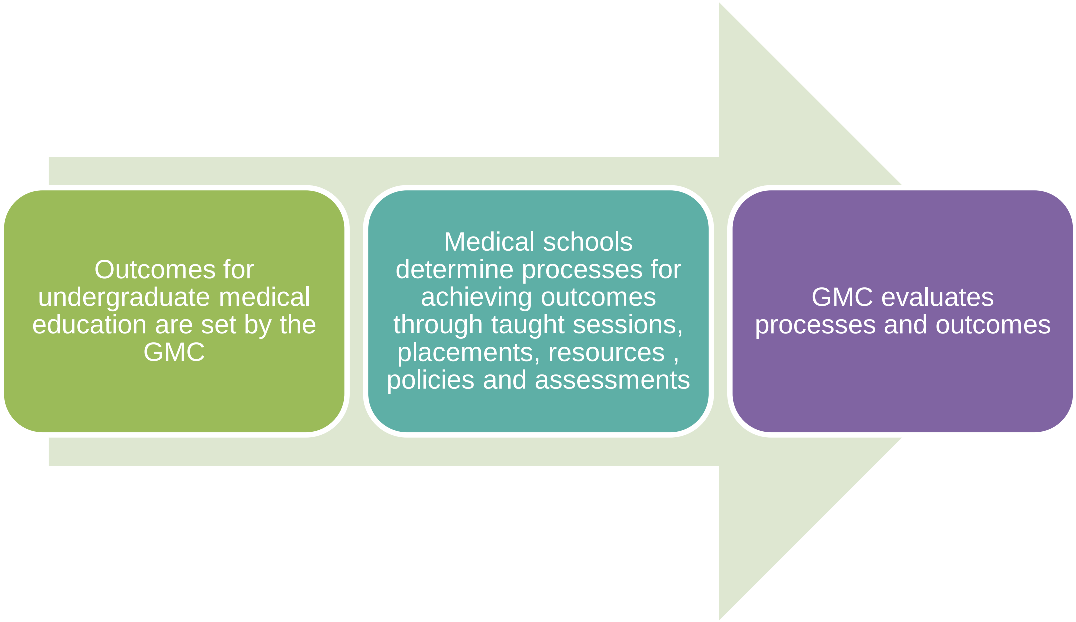


Figure G. Regulatory Processes Of Undergraduate Medical Education

Commentators observe the current curriculum regarding scientific content remains contested in terms of dominant influences from societal and professional concerns. Grant (2010) writes that there are "battles" fought by curriculum designers regarding what topics students should learn and "where the science base stands". Whitehead (2013) observes that one cause is that the science base for medical education is simply too vast and that there is "too much to know", or too much to condense into a curriculum limited over the duration of the undergraduate training. Even more fundamentally, however, is the question regarding how medicine defines scientific approaches and evidence, as this influences what sciences count as worthy of inclusion within the undergraduate curricula (Maudsley & Stivens, 2000).

4.3. The Influence Of Tomorrow's Doctors On Medical Education Curricula

Tomorrow's Doctors was first published in 1993 and was influenced by the *Flexner Report* (Leinster, in Cavenagh et al, 2011, Van Damme, 2005). The *Flexner Report,* written by one author Abraham Flexner, published in 1910 and commissioned in 1908 by the American Medical Association, recommended restructuring of medical education in the United States and Canada. The report viewed the teaching of science as the "key to high-quality medical education" (Dornan, 2005). *Tomorrow's*

Doctors in turn influenced curricular guidance and recommendations for undergraduate training both within the UK and internationally. The two notable documents sharing current competency framework guidance equivalent to *Tomorrow's Doctors* are *CanMEDS (*2005 and 2015*)* and *The Scottish Doctor* (2008).

4.3.1. Tomorrow's Doctors (1993)

The 1993 version's emphasis was on the process and methods within teaching and learning in medical education. This inaugural version of *Tomorrow's Doctors* advocated a scholarly approach to medicine, defined in the document as a hybrid of art and science. The biomedical sciences share importance within broader curricula aims that include behavioural, social sciences and humanities disciplines. This approach to learning in medicine would resonate with Flexner's approach in his 1910 report. The Flexner report had been concerned with approaches to learning rather than specific curriculum content, "medical education is an educational rather than a professional problem" (Flexner, 1912). Flexner was not a medical clinician and was chosen to prepare the report based on his educational background. Whitehead (ibid.) argues that the Flexnerian view of a medicine was of the practitioner adopting a scientific approach to medicine, a '*scientist*-doctor', as well as a practitioner of applied science. She argues that Flexner, as an educationalist and not a doctor, espoused the view of science as a form of knowing, which "was more important than the details of curricular content" (p.28). In addition Flexner had a view on scientific methods. This was expressed in 1925 and indicated an approach to science in medicine that is socially situated, constructed and theory bound,

> *"Scientific medicine in America…is today sadly deficient in cultural and philosophic background."* (Flexner, 1925).

> *"Science resides in the intellect, not in the instrument."* (Flexner, 1925).

Tomorrow's Doctors (1993) emphasised its primary aim to be that of developing within medical students an attitude to learning that embraces critical study and independent thought, obtained through curiosity and experiment. The publication's mood and epistemological approach to scientific thought and development was very much Flexnerian in tone.

The document is loose in detail of curriculum outcomes, expressly putting this secondary in importance to the approach to learning. The metaphors of medicine as tentative and exploratory is achieved through the use of words and phrases referring to scientific approaches to medicine as "*a discovery of how knowledge is acquired", "understanding research methods"* and "*an ability to evaluate evidence"* (p.13). The document states medical students need to understand a *"range of problems*" that imply a "*range of solutions*" (p.13). This necessitates epistemological and behavioural attributes, including the "*coping with uncertainty*" and "*adaptation to change*" (p.15). The document's tone concentrates at length on knowledge acquisition, on the attitudinal approaches toward research and scientific enquiry. The authors articulated a belief that this could be fostered through problem-orientated learning approaches and the use of elective special study modules within the curriculum that develop, through research, critical exploration of a broad range of subjects relevant to medicine. The guidance document states these modules should "comprise a substantial component of the curriculum" and serve as vehicle for knowledge and understanding of the sciences basic to medicine, defined as:

i/ the discovery of how knowledge is acquired

ii/ an understanding of research methods

iii/ an ability to evaluate evidence (p.13).

In terms of epistemology the 1993 document recognises and emphasises the role in developing scholarly approaches to obtaining scientific knowledge in medicine. Although the document fails to specifically define scientific methods (and refers to one single scientific method) there are repeated references to scientific knowledge in medicine that is something to be explored and evaluated using a range of techniques that utilises social context and ethical philosophical approaches. Research methods are cited as the means to investigate knowledge and this is linked with social and environmental factors that may produce variable results. In this way the document recognises that medicine is socially situated and defined and that knowledge may be partial or tentative.

Tomorrow's Doctors (1993) repeated forewarnings, from pre-1990s British undergraduate guidance documents, of the perils from cramming and overloading the curriculum and putting pressure upon students to memorise and reproduce swathes of factual bio-medical data.

> *"The memorising and reproduction of factual data should not be allowed to interfere with the primary need for fostering the critical study of principles and the development of independent thought. The student should acquire and cultivate the ability to work independently" (p.5).*

Later versions of *Tomorrow's Doctors* (2003, 2009), in direct contrast, moved to a listing of intended outcomes to be achieved with few comments regarding the nature of what constituted a 'scholarly approach'. The approach to knowledge is neglected in these later revised publications relative to the first inception of the guidance document.

4.3.2. Tomorrow's Doctors (2003)

In 2003 *Tomorrow's Doctors* was revised. The authors are not listed, but an internet search suggests that contributors were medically qualified academics, rather than educationalists. The document states (p.4) that the *Tomorrow's Doctors* series was intended as an attempt to emphasise learning processes (education in a medical school setting) in contrast to gaining knowledge (via apprentice style learning alongside working physicians). In the 2003 version, the essay style from the 1993 document was replaced with a format recognisable in the subsequent 2009 version of the guidance, where the outcomes and competencies students are expected to meet are listed (science as observable behaviours). Gone is the stressing of approaches to knowledge acquisition that are constantly questioning and self-critical, as in the 1993 version. This is replaced by learning processes that emphasise the evaluation of knowledge, including acquiring the generalised skill of being able to "solve problems" (p.14).

In the body of the 2003 version scientific methods are referred to in the plural (p.10). This suggests there may be different ways of approaching a scientific question and echoes the plurality of mind-set to scientific enquiry that is present in the 1993 version. What is included in "scientific methods" is summarised as encompassing "technical and ethical principles when designing experiments" (p10). What is lost by this definition is recognition of methods that are not defined by 'technical experimentation' and the suggestion that the doing and thinking in science is something associated with laboratories. The 2003 version is the only version to provide in the glossary a definition of method in science. In this glossary the plurality when referring to of 'scientific methods' referred to in the body of the document has been lost and there is one approach to scientific research.

> *Glossary: Scientific Method*
>
> *"A rational approach to explain natural events and processes by formulating, testing and modifying a hypothesis." Tomorrow's Doctors, 2003* (p.33).

This distils the nature of science into a single approach and cuts off the notion that there are contested debates regarding the nature of science and scientific approaches. McComas describes the belief that there is a single common series of steps followed by all research scientists as one of the "most pervasive myths of science" (1998, p.57). The definition provided in the *Tomorrow's Doctors* (2003) glossary is of one scientific method and a definition that is rationalistic, empiricist, deductivist and positivistic. The key words of experimentation (in the main body of the document) and notion of linking this with a hypothesis and rational approach (in the glossary) define this positivistic approach. Such an approach is described as the idea that the claims of science promotes objectivity and a reductionism to verifiable truths, and does so value free and independent of the investigator's psychological and social milieu (Aikenhead, 1987. Playle, 2005. Goldenberg, 2005).

4.3.3. CanMEDS (2005) And The Scottish Doctor (2008)

In 2005 the Royal College of Physicians and Surgeons of Canada (RCPSC) initiated and produced *CanMEDS* (Frank & Danoff, 2007). The RCPSC is the independent certifying and accrediting body for specialty medicine in Canada (all disciplines except family medicine) and is the Canadian equivalent of the GMC in the UK. This document took up the baton of *Tomorrow's Doctors'* outcome and competencies framework by categorising a condensed list of desirable outcomes and behaviours from medical students. *CanMeds* was described by Frank & Danoff (ibid) as created to address "concerns in contemporary medical literature" (p.643) regarding doctors being able to meet the broad societal and population healthcare needs. Under the heading, *scholar and professional,* approaches to learning are described in terms of being critical, posing scholarly questions, searching for evidence and choosing appropriate methodology. However, the document does not explicitly label these approaches as 'scientific' but the definitions to what is a scholarly approach is recognisable as a Flexnerian scientific approach.

In contrast to the short list of scholarly approaches to scientific query in *CanMEDS,* the current version of *The Scottish Doctor* (2008), though still outcome and competency based and mapped to *Tomorrow's Doctors* (2003), provides a much greater list of attributes involved in decision making, clinical reasoning and judgement, and which assumes there are a range of approaches to exploring medical and scientific questions. *The Scottish Doctor* has 12 domains of learning outcome competencies. The domain, *decision making skills and clinical reasoning and judgement,* contains competencies relating to critical thinking, research and scientific methodologies, creativity/resourcefulness and coping with uncertainty and error in decision making. The types of skills graduates should possess are listed as;

- Adopting an inquisitive and questioning attitude where appropriate and applying rational processes;
- Knowledge and appreciation of quantitative and qualitative methodologies, including the differences between them and their appropriate usage;
- Applying knowledge of scientific methodologies to critically evaluate research findings.
- Innovative use of knowledge, techniques, technologies and methodologies;
- Appreciating that uncertainty exists and that sources of uncertainty might include: oneself, the environment, the patient, and limits of knowledge (p29 – 30).

Although the document champions a range of approaches to thinking about medicine that on the face of it are reminiscent to a Flexnerian and Tomorrow's Doctor (1993) model of the doctor scholar, it is noteworthy that these attributes are listed as types of problems that arise in a clinical domain, the 'doing' of science, rather than the 'knowing' of science. The domain *basic, social and clinical sciences and underlying principles*, tells us there are a range of scientific approaches or scientific frameworks including qualitative and quantative methods. However, as with *CanMEDS,* medical uncertainty is associated with clinical decision making and implies that this may be overcome, either through improved communication or increased knowledge by the adoption of a problem solving approach.

4.3.4. Tomorrow's Doctors (2009)

By 2009, and stating in response to concerns about scientific education (but not declaring what these concerns were) we find a revised *Tomorrow's Doctors*, trebled in length from that of earlier versions due to curriculum content being heavily defined in listing technical competencies for undergraduates to become proficient with. A range of scientific approaches, alluded to in previous versions, have been reduced to a singular scientific method by the 2009 version. The 2009 version is a manual full of prescriptive curriculum content for investigative, diagnostic and therapeutic procedures but disconcertingly with an absence of definitions for science, scientific methods and approaches. Science had become something that is 'done', measured by competencies, rather than a pursuit of and characteristics about 'knowledge'. In the outcome, *doctor as scholar and a scientist,* the document tells us there are theoretical frameworks governing the approaches to psychology and social sciences with respect to medicine.

> *Outcome 1 − The Doctor As A Scholar And A Scientist*
>
> *The graduate will be able to…apply theoretical frameworks of psychology to explain the varied responses of individuals, groups and societies to disease p15).*

The graduate will be able to…apply theoretical frameworks of sociology to explain the varied responses of individuals, groups and societies to disease (p16).

In contrast the document implies the scientific principles within bio-medicine, population health and medical research are free from any such theoretical frameworks by omitting statements of such in the desired outcome competency heading.

Outcome 1 − The Doctor As A Scholar And A Scientist

The graduate will be able to apply to medical practice biomedical scientific principles, method and knowledge relating to: anatomy, biochemistry, cell biology, genetics, immunology, microbiology, molecular biology, nutrition, pathology, pharmacology and physiology (p.14).

The document implies that there is a single method to the obtaining and advancement of bio-medical knowledge. The 'method' is defined in Appendix 2 of the document quoting from the European Law Medical Directive. The epistemological view of scientific knowledge espoused in the quote is positivistic in its definition of scientific approaches as applied to medicine, implying that on graduation medical students should have:

"Adequate knowledge of the sciences on which medicine is based and a good understanding of the scientific methods including the principles of measuring biological functions, the evaluation of scientifically established facts and the analysis of data." EU Council Directive 93/16, 1993; article 23, para 1 (p.83).

The quote refers to 'methods' within scientific approaches and suggests, similarly as in the *Tomorrow's Doctors* (2003) document, that all scientific approaches within the study of medicine share a commonality of quantitative research centred upon biomedical problems where 'facts' can be discovered through the application of measurement and data analysis. That the publication moves between referring to science method and methods throughout the text suggests a reflection of the authorship comprising of a range of contributors, but also a belief that approaches can be reduced to one way of 'doing' science. As the versions of *Tomorrow's*

Doctors were published by the GMC, it is not surprising that review groups for the guidance versions set up by the GMC comprised of members from clinical practice, medical education and health employers, in addition to patient groups (see GMC undergraduate board minutes; 10 Nov 2009). Experts from general education (in the sense that Flexner was such) were not included; thus the balance from educationalists to clinicians changes in the influence of Tomorrow's Doctors.

Tomorrow's Doctors (2009), is the first version of the undergraduate curriculum guidance to explicitly identify and make a separation of scientific approaches between bioscience and social sciences/psychology. In this document lies the assertion that the study of social sciences and psychology encompass a range of approaches and theoretical frameworks and that knowledge models within these disciplines are contextual and subjectivity constructed. In contrast the publication associates bio-scientific knowledge with a universally accepted single method, suggesting that this is knowledge to be discovered as objective truth.

4.3.5. CanMEDS (2015)

In the 2015 revised version of *CanMEDS* competency framework, there are seven areas of competencies that medical students work toward. These are: *medical expert; communicator; collaborator; leader; health advocate; scholar; professional*. Knowledge relevant to medicine is defined in the competency *medical expert* and is limited to "knowledge of the clinical and biomedical sciences relevant to their discipline" (p.4). The document states that a medical expert will "recognize and respond to the complexity, uncertainty, and ambiguity inherent in medical practice" (p.4). However, this falls short of acknowledging complexity, uncertainty and ambiguity that is inherent in the knowledge that informs medical practice. In the competency, *scholar,* the document says practitioners will, "recognize practice uncertainty and knowledge gaps in clinical and other professional encounters and generate focused questions that address them" (p.14). This suggests that medical uncertainty is encountered during the practice of medicine and implies that 'knowledge gaps' can be addressed to reduce medical uncertainty.

4.3.6. The GMC (2015) Review Of *Tomorrow's Doctors*

In 2015 the GMC launched a public consultation on *Standards For Medical Education And Training*. This included a review of Tomorrow's Doctors to question the feasibility of developing a single set of standards for both undergraduate and postgraduate medical education and training. The consultation document set out in four themes, the fourth being *developing and delivering curricula and assessment.* The only reference to sciences in medical education in the document is contained in the requirements for undergraduate curricula and states; "learning opportunities that integrate basic and clinical science, enabling them [medical students] to link theory and practice." The document has nothing to say regarding scholarly approaches to knowledge acquisition or knowledge that is relevant to and integral to the practice of medicine that is not either a basic science or a clinical science. By omitting any references or definitions to scholarly approaches to the study of sciences relevant to medicine, this suggests universal agreement on what the nature of science in medicine encompasses.

4.3.7. Temporal Epistemological Trends In Key Undergraduate Curricula Publications

In my analysis of the discourses about science, scientific methods and evidence based research I identified temporal trends regarding epistemological assumptions underlying science and its nature in medicine. The documents were limited to only the UK and North America, However, there were themes from these documents sharing a common ancestry in the Flexner reports. Starting with the Flexnerian epistemological position of constructed and contextual models of knowledge, there was a change over time to viewing clinical and biomedical knowledge in positivistic epistemological terms; as associated with discovered, universal facts. However, research and the social sciences were more associated with models of knowledge that were constructed and contextual. Knowledge as clinical uncertainty is more likely to be framed in contemporary times as something that can be managed, linking clinical uncertainty with biomedical certainty. The most recent trend (GMC, 2015) in curricula documents is to remove statements hinting at epistemological viewpoints from the curricula documents; suggesting that science in medicine is concerned with its application and not the knowledge that frames practice.

Numbered dot on Figure H below	**Date Published**	**Name of Publication**	**Epistemological standpoints on scientific knowledge in medicine**
1	1910	Medical Education in the United States and Canada (Flexner)	Constructed and contextual models of knowledge.
2	1912	Medical Education in Europe (Flexner)	Constructed and contextual models of knowledge.
3	1993	Tomorrow's Doctors (GMC)	Constructed and contextual models of knowledge.
4	2003	Tomorrow's Doctors (GMC)	Knowledge as discovered, universal facts.
5	2005	CanMEDS (Royal College of Physicians and Surgeons of Canada)	Knowledge is tentative and uncertain in the clinical domain (science as doing rather than science as knowing). Clinical uncertainty arises through knowledge gaps or limitations of knowledge but can be addressed to achieve certain knowledge through the generation of focused questions.
6 7	2008	The Scottish Doctor (Scottish Deans Medical Education Group)	Constructed and contextual models of knowledge (scientific research). Knowledge is tentative and uncertain in the clinical domain and in evidence based medical research. Clinical uncertainty arises through knowledge gaps or limitations of knowledge but can be addressed to achieve certain knowledge through the generation of focused questions.
8 9	2009	Tomorrow's Doctors (GMC)	Knowledge as discovered, universal facts (bio-medical knowledge). Constructed and contextual models of knowledge (social sciences and psychology).
10	2015	CanMEDS (Royal College of Physicians and Surgeons of Canada)	Knowledge is tentative and uncertain in the clinical domain (science as doing rather than science as knowing). Clinical uncertainty arises through knowledge gaps or limitations of knowledge but can be addressed to achieve certain knowledge through the generation of focused questions.
N/A	2015	Standards For Medical Education And Training: A Public Consultation On Our Draft Standards (GMC)	No discourses on the scientific approaches to knowledge in medicine.

Table 6. Time Line Of Influential Publications Affecting UK Medical School Curricula And Epistemological Views On Scientific Knowledge In Medicine

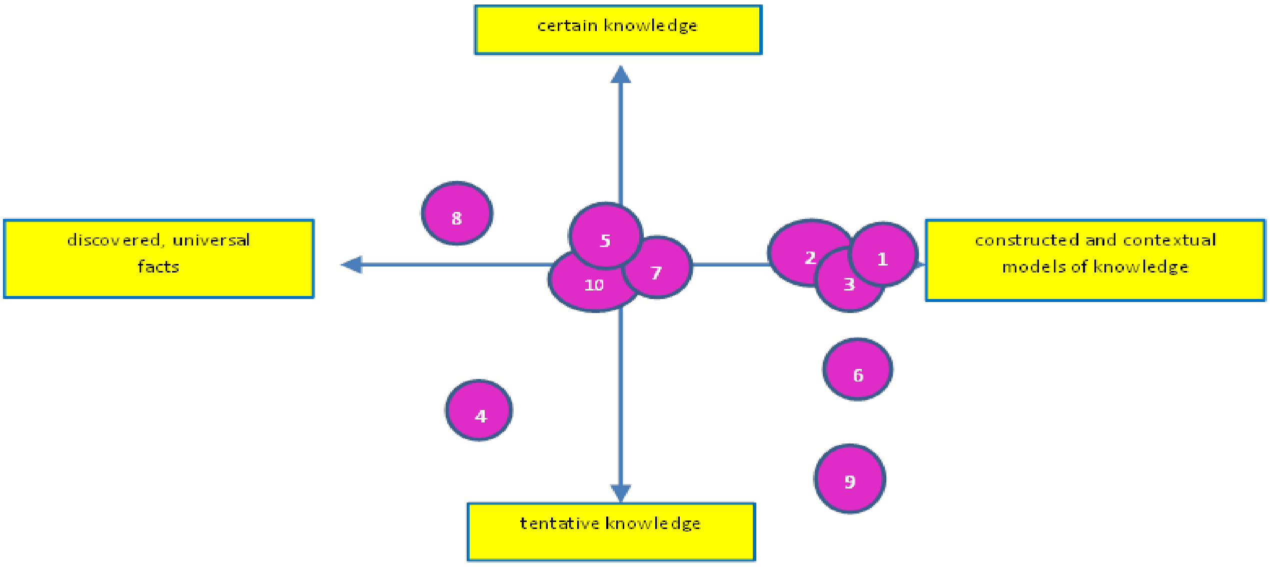


Figure H. Mapping Of Discourse Analysis Statements About Scientific Knowledge In Medicine Found In Curricula Documents (From Table 6) To Theories Of Epistemological Development

4.4. University Of Exeter Curricula Documents

The University of Exeter Medical School undergraduate study entry brochure provides prospective medical students an overview of the BMBS course curriculum. The structure of learning in Years One and Two, Years Three and Four, and Year Five are laid out in the brochure. Years 1 and 2 are described as the time when the scientific foundations of medicine are learnt within a clinical context. Medical students will experience a curriculum based on the human life cycle, with a “core knowledge of human and life sciences and public health,” relating this to the patient. The brochure states medical students will experience a broad curriculum, with the emphasis on learning critical thinking and analytic skills within scientific knowledge is referred to specifically under the heading *special study modules* (p.4). For Years Three and Four under *special study modules* (p.6), the socially situated and contextual aspect of medicine is alluded to with reference to ‘working together’ and ‘the healthcare management’ special study units. In these modules medical students are told that they will experience collaborate learning across primary and secondary care, that includes collaboration with non-medical colleagues in healthcare teams and develop an understanding of the complexity of healthcare management.

The medical school *BMBS Student Handbook* is a guide outlining the BMBS programme with information about studying at the medical school. The aims of the programme are linked explicitly to the *Tomorrow's Doctors'* outcomes. The handbook assumes medicine has a scientific base, Years One and Two medical students will, 'acquire knowledge of the scientific basis of medicine' (p.3). In the handbook, mapped to *Tomorrow's Doctors Outcome 1 − The Doctor As A Scholar And A Scientist,* are five standards the medical school expects graduating medical students to have achieved;

- Apply to medical practice the bio-medical scientific principles, method and knowledge
- Apply psychological principles, method and knowledge to medical practice
- Apply sociological principles, method and knowledge to medical practice
- Apply to medical practice the principles, method and knowledge of population health and the improvement of health and healthcare
- Apply scientific method and approaches to medical research.

Only the final bullet point, in relation to medical research, is the notion of a range of approaches to scientific modelling indicated (this bullet point is taken directly from *Tomorrow's Doctors* (2009). The handbook standards mirror a narrow and single method for approaching scientific enquiry that is found in the GMC *Tomorrow's Doctors* (2009). The suggestion of one scientific method grates with Ryan and Aikenhead (1992), who believe this either stems from a logical reconstruction of the re-writing of the history of science or a misconstruction of the description of how scientific work is actually done. They state "epistemologists have generally agreed that there is no such thing as the scientific method" (p.572).

When new medical students enrol on the BMBS course a suggested reading list is distributed to them. The reading list for the 2013 intake had 22 suggested books and the 2014 intake had 27 books on the list. By analysing the contents of the books on the list the following categories of topics emerged:

Books by topic	**2013 Textbook List n=22**	**2014 Textbook List n=27**
Biosciences	12	15
Clinical Skills	1	1
Population Health	4	5
Psychology	1	1
Research Skills	2	3
Professionalism	1	1
Medical Ethics	0	1
Medical Fiction	1	0

Table 7. 2013 and 2014 Key Textbook List For New Medical Students

Books relating to the bio-sciences made up more than 50% of each list. This may mirror, reinforce and/or fail to challenge medical student expectations of the nature of medicine when they arrive at medical school. The population health category included textbooks on the subjects of public health and sociology. In 2013 the list included a novel written by a surgeon about a family of doctors working in a Rwandan hospital. The professionalism textbook was on the topic of skills for communicating with patients. I have not mapped these document to the chart developed to indicate epistemological beliefs regarding the nature of science in medicine (Figure D). These books were not analysed in detail and were broadly aligned with *Tomorrow's Doctors* (2009).

4. 5. Summary Of The Chapter

Flexner's vision of an educationally well rounded competent graduating medical student in North America and Europe with knowledge of history, psychology, sociology and philosophy as a way of understanding the nature of science within the discourse of medicine has flowed, then ebbed over the 20th and into the 21st Century according to my analysis of curricula policy statements stemming from Western-centric countries claiming to have curricula influenced by Flexner. In 1993 *Tomorrow's Doctors* still carried forward Flexner's sentiment with the discourse of developing a scholarly scientific practitioner, but this emphasis was in retreat by the turn of the 21st Century with the advancement of outcomes and competency based educational standards where medical students experience science as something to be practiced. Later versions of *Tomorrow's Doctors* and policy guidance documents from the UK and North America moved to inclusion of curriculum content that is dominated by discourses of science and an epistemological stance of science in medicine that is defined as the practicing of bio-scientific skills and competencies to be mastered, rather than an approach to thinking about medicine and science. For Whitehead (2011, 2013) this shows a disconnect, and failure to integrate within the curriculum science in medicine as both a scholarly approach and an application of such. I sit in agreement with Whitehead sharing concerns that the scholar has been subsumed by the scientist and that the reinforcement and centrality of bio-medicine in the curriculum marginalises other important knowledge domains. By *Tomorrow's Doctors* (2009) science in medicine is narrowly defined, taken for granted and usually it is implied that there is a single scientific method that all medical practitioners as scientists follow. *The Scottish Doctor* comes closest in explaining characteristics of what makes research scholarly and scientific within outcome based competency framework. Through discourse a 'lexical label' becomes a social fact, an accepted truth through 'normalising' language (Park, Pelletier & Klingenberg, 2014). Some discourses become more powerful and go unquestioned. For example, that medicine is scientific, factual and progressive, despite comment that a clearer understanding of science, its strengths and limitations is beneficial to the development of critical thinking within the medical profession (Maudsely & Stivens, 2000). Rambihar (2000) wrote that the 21st century epistemologically heralded the collapse of "normal science." That normal science (before 2000) referred to a puzzle solving approach, with uncertainty managed and values unspoken (uncertainty in medicine in this respect being addressed as a feature of clinical practice and not including uncertainty as an aspect of knowledge in itself). Rambihar describes modern science (including science in medicine), emerging from the new science of nonlinear dynamics, as recognising irregularity, subjectivity and uncertainty, as intrinsic and fundamental. However, current undergraduate key curricula and policy documents examined suggest this is an optimistic interpretation of the meaning and use of science and evidence in general in medicine and that the nature of science in medicine remains both poorly and epistemologically narrowly defined. The implications of these epistemological themes around the breadth of definition of science in medicine, the importance of science in medicine and the relative valuing of certain topics over others (seen in the perceived volume of curriculum content expressed through numbers of textbooks and lectures), science versus scholarship in medicine and uncertainty as a feature of medical practice rather than medical knowledge will be discussed in Chapter 8.

Chapter 5: Data-Led Participant Findings

5.1. Introduction to the Chapter

In this chapter I will present the results of the data-led inductive analysis from engaging with the participants of medical students and faculty during task group sessions and interviews. The emergent key themes and in-depth conversations leading to sub-themes will be presented (see section 3.5.7 for an explanation of the data-led analysis approach in Chapter 3 Methodology).

5.2. Participants

The research participants were 25 Year One medical students who took part in task groups using cards containing descriptive words about the nature of science to explore individual beliefs about science, and experiences of learning about science. This was followed up with in-depth interviews with 12 of the Year One task group participants, 14 Year Three medical students (see Appendix 9 for medical student participant demographic data) and 16 faculty, with a range of teaching commitments with the medical school.

Year One medical student participants took part in task group sessions during their first term after arriving at the medical school. Further interviews with Year One medical students took place during the second term of their first year. Interviews with Year Three medical students took place in the first and second term of the academic year. Interviews with faculty took place throughout the academic year (see sections 3.2.4 for participant phase methods rationale and section 3.5.3 for participant recruitment).

Method	Participants	Total number	Number of females	Number of males	Age range of medical students and average overall age
Task groups (n = 5)	Year One medical students	25	14	11	18 – 31 years (average age 19.8 years)
Interview	Year One medical students	12	7	5	18 – 31 years (average age 21.3 years)
Interview	Year Three medical students	14	6	8	20 – 40 years (average age 23.4 years)
Interview	Very close faculty	6	4	2	Data not collected
Interview	Close faculty	7	3	4	Data not collected
Interview	Distant faculty	3	2	1	Data not collected

Table 8. Participant And Task Group/Interview Details

Each participant was assigned a unique identification code for anonymity. For example:

- M101 is a male Year One medical student. M indicates they are male, 1 indicates the first year of study and 01 indicates they were assigned number one in this group of participants.
- F305 is a female Year Three medical student. F indicates they are female, 3 indicates the third year of study and 05 indicates they were assigned number five in this group of participants.
- FAM02 is a male very close faculty member. FA indicates they were very close faculty based on contract type and FTE teaching commitments, M indicates they are male, 02 indicates they were assigned number two in this group of participants.
- FBF03 is a female close faculty member. FB indicates they were close faculty based on contract type and FTE teaching commitments, The middle F indicates they are female, 03 indicates they were assigned number three in this group of participants.
- FCF01 is a female distant faculty member. FC indicates they were distant faculty based on contract type and FTE teaching commitments, F indicates they are female, 01 indicates they were assigned number one in this group of participants.

Where it was not possible to identify an individual participant within a Year One medical student task group session, due to similarities in voice sound, the voice has been labelled by gender and date of task group session.

5.3. Analysis And Key Themes

A single coding framework was developed across all participant groups, driven by the interview data content and emergent key issues and themes within. A chart of the single coding framework was used for each group to show what each group said under each theme/sub-theme (see Appendix 8 for inductive coding framework headings/subheadings document). This enabled me to identify issues raised by one group but not another. The coding framework was influenced by Ritchie and Spencer's principles of qualitative data analysis (1994). The data-led inductive analysis led to three key themes, which were then further broken down into sub-themes.

- Theme 1: Nature of science (personal epistemology). Under this theme was coded participant's individual beliefs about science and scientific knowledge. In general, the nature of science refers to key principles and ideas which provide a description of science as a way of knowing, as well as characteristics of scientific knowledge.
- Theme 2: Nature of medicine. In this theme was coded participants' perceptions of medicine, for example as a scientific discipline and what might make medicine scientific.
- Theme 3: Experiences of education. Under this theme was coded participants' reflections upon their experiences of education, whether as students or educators. Captured within Theme 3 are aspects of the formal, informal and hidden curricula with respect to power and influences impacting upon how medical students developed independence of learning and development of personal epistemologies what perceived value participants gave to topics within the curriculum in terms of scientific relevance to medicine.

These themes will now be presented in order.

5.4. Theme 1: NATURE OF SCIENCE

Under this general theme were participant's individual beliefs about science and scientific knowledge. In general, the nature of science refers to key principles and ideas which provide a description of science as a way of knowing, as well as characteristics of scientific knowledge. The nature of science is related to epistemology of science rather than scientific content. (Where participants groups mapped to theories of epistemological development regarding the nature of science this is presented in Chapter 6: Theory Led Data Analysis).

5.4.1. Personal Epistemologies

Year One medical students typically verbalised areas of medicine and health care that they perceived and defined as scientific subjects, but a scientific approach was less well-defined by this group. Year One students were likely to see scientific approaches in terms of logic and proofs; these students had difficulty in reconciling that competing scientific theories may coexist.

> *"… obviously, yeah, science wouldn't improve if people weren't disproving other people's theories... How certain is … um, I guess I'd say if you – like anatomy, there's no disagreement: that is a leg and that's what everyone calls it… whereas the things you learn in lectures and the things we'll learn in later years about what drugs to give and certain procedures, will change, because that knowledge is always being, like, revisited and bigger trials, new drugs…"*
>
> Participant M104 in task group

> *"No, I think that most students don't look at science as theory they look at it as truth. 'Cause, I mean, that's actually the goal of science isn't it, to create theory into truth…."*
>
> Participant M108

Year three students tended to be aware of science containing uncertain and tentative knowledge. These students said that scientific knowledge was something that was evidence based and not always ethical.

" … So I think it is hard to appreciate that, that's what science is, it's not, you know, there are no facts out there, there's just loads of theories and you've got to go for the one where the evidence points to it the most. Which is why doctors are constantly changing their treatment, changing their understanding of things, because they rely on evidence to sort of decide where, you know, what's going on."

Participant F304

"Currently I'm looking at the role of genetic counsellors in the multi-disciplinary team and I'm basing around a case of hereditary breast cancer. So it's looking at kind of the BRCA1 and BRCA2 genes and that's quite interesting because although they're kind of, they're the most common ones, they still only account for maybe 25% of actual hereditary breast cancer, so it does show a lot the uncertainty present in science at the moment, even for a really common disease."

Participant M303

" … I did this SSU looking into this [treatment for diabetes]… *and I noticed that all of the work that was pointing in a positive direction for this particular medication or this particular angle of research that maybe a treatment cum cure for Type 2 diabetes… And then I looked into it further and I found that… one of the top people, you know, the last names on the paper, so to speak, he had a patent...researchers have a vested interest in having their research published, obviously, 'cause otherwise they don't get funding. "*

Participant M302

All the very close faculty talked about science as theory driven, with a variety of approaches to scientific enquiry. They also tended to acknowledge that scientific concepts contained uncertainties and verisimilitude was socially situated.

"So my background being biomedical science I would still say there are underpinning theories and methods and knowledge that you can use as your scaffold to then pin all these clinical experiences on. And I wonder whether, if we were even clearer as a faculty about what those – what are the bits we're really going to emphasise, so they have something a bit more

to get hold of… I don't know where that comes in. It comes in a bit in the Problem Based Learning and possibly we need more skills in being able to do that – or – but it definitely comes in in other parts of the curriculum as well…when I joined here… initially to do biomedical science research I was looking for a truth, and then as you become a more experienced researcher I was probably moving towards – ah, but it depends on which way you look at it what that truth is.. I suddenly became aware of – oh you could look at it as though there wasn't a right answer! Oh I hadn't ever thought of that! And I think, actually, understanding that really helped me a lot in science."

Participant FAF05

"You know, because there's still this perception in the basic science, it's concrete, you know…and I argue quite strongly that science is not concrete, you know, most of it's theory driven. Yes, there are bits that are more concrete than others, but actually a lot of the science is not solid, but there's this belief, and I think that comes from the way science is taught at A level and GCSE: you learn a load of facts and a load of theories and principles and you learn to apply them and if you can do that you understand science."

Participant FAM01

"… from my background, structural biology, you solved the structure of a protein on faith that it would show you something interesting and you worked out what questions it answered once you'd got the structure! I mean, and that might sound like really bad science [laughs] to a lot of people but, you know, it's advanced our knowledge no end and, you know, people get good publications out of it and it leads to a whole load of other science which may be more kind of focused research question driven but there's more than one way to do science …"

Participant FAM02

Two close faculty speaking about the nature of science talked about established knowledge in terms of truth and facts, in a way that was spoken about in more tentative terms than the very close (typically non-clinical) faculty.

"I think there's a need for the recognition that they need to garner, glean facts and recognise where they're missing facts and so they have to go and find the facts and the knowledge – or the information before it turns into knowledge, which implies some degree of application...I think the scientific foundation and the established knowledge and the development of new knowledge is critical."

Participant FBF01

"[medical students] *come in, they present a piece of evidence and what they think it means, and then we pull it to pieces and they realise that actually it's really difficult, even for really well designed and funded studies, it's really difficult to get to the truth, and very easy to be misled by, you know, a couple of P values and certainly by an abstract."*

Participant FBM04

5.4.2. Scientific And Non-Scientific Methods

Medical students discussed what they considered to be perceived attributes and approaches toward scientific and non-scientific methods. Year One medical students overwhelmingly expressed limited insight into the role of theory within scientific methods, although there was agreement that the method used would be evidence based and modelled upon a quantative experimentation approach. One person talked about the role of ethics within research and considered this role to be the purpose of peer review. They also thought peer review had a role in reproducing research, and by this established accepted knowledge.

"science, for me…I suppose it really does sort of depend on, like, whether you're using evidence or whether you're using research to inform your decisions. If you're doing that it is a scientific approach, 'cause it's kind of the equivalent of experimentation."

Participant F107

"…facts can be manipulated and used by people for, like, less than moral reasons, but that's how science works, it has to be, like, peer reviewed, it has to be tested, retested, before anything solid can come out of it and I think that's obviously a really healthy thing."

Participant M105 in task group

There remained a generally naïve and positivistic view of scientific methods amongst Year Three students. A scientific approach was talked about as being unbiased, involving experimentation and being about a reductionist approach. However, some Year Three students appreciated complexity and subjectivity in approaches to research in medicine and evidence and pattern recognition as a pragmatic alternative to 'proof'.

> *"*[in science] … *most of the time there's a theory and you go out to either disprove it or prove it, you know, and there's only – there might be two or three ways of looking at something, but that's about it."*

Participant F304

> *"But I think when your pattern recognition is based on a pool of, you know, thousands and thousands of patients, then it's going to be really pretty good and pretty scientific, and you don't need to go and prove it, so yes, they use pattern recognition probably an awful lot more than they do looking for individual proofs… So I'm not sure how I'd really define scientific thinking… So asking questions, basic questions about everything rather than making assumptions...Being able to repeat the result is how you prove something scientifically, I suppose… pure science is about reducing something to one problem and seeing if you change one variable, what happens. But that never happens in Medicine, if each of us is different, nobody, even identical twins have different environmental factors and are different, it means that you can never truly repeat the same experiment over the same set of people, so there will always be variability because the subject that we're dealing with is too big and you can't reduce it down to one thing…it's only when stuff is reduced completely that science really works and Medicine cannot be reduced, you know, everybody's different, everybody's going to react in different ways."*

Participant M306

5.4.2.1. Subjectivity/Objectivity

In considering 'scientific and non-scientific methods,' Year One medical students used the contradictory terms 'subjective' and 'objective' as markers regarding claims about the status of ‘truth’ in science and the validity of scientific methodological approaches. Comments centred on the natural sciences in medicine as able to be known or discovered. Year One medical student participants often closely linked this with objectivity in knowledge and the development of ‘rules’ of thought.

> *“I think, I don’t know, there’s obviously elements of subjectivity and objectivity in terms of medicine, I think, ‘cause the body has so many complexities, like it’s difficult to know, like everything… there’s still a lot more to understand which will lean towards subjectivity, but then you’ve got like anatomy that just goes back a long time, which you think – well it’s pretty standardised, it’s sort of more set in stone.”*
>
> Participant M105 in task group

Where human agency was seen to affect the result of a scientific ‘rule’, as in a patient with a complex illness or a social science view of the human condition, participants linked this with interpretation, uncertainty and subjectivity of knowledge. Subjectivity was seen as casting doubt on the rigour and subjectivity of a methodological approach.

> *“Definitely, I think social sciences are more subjective, like psychology …… sociology.”*
>
> Participant F102

> *“Yeah, and that was the other thing, once you take people out of the equation, like physics or chemistry, it’s just – it’s not about your perception of how they work as such, it’s just ‘this is how it works.’”*
>
> *Male participant from task group 31 Oct*

5.4.2.2. Constant/Changing

Medical students discussed science and scientific knowledge in terms of having constancy; such as scientific approaches as unvarying or scientific knowledge as fixed and unchanging. Year One medical students talked about scientific results as changing, affecting knowledge; however they held contradictory beliefs about whether key theories remained fixed.

> *"Well, I think, like, what we studied back in A level and in college everything is more like the foundation of science, so still fairly concrete and doesn't really change, but what you learn in university it's continuously getting proved and disproved, so that could change over time. "*
>
> Participant M111

5.4.3. Authoritative Knowledge

In this sub-theme medical students discussed science and scientific knowledge in terms of knowledge imparted from experts or supervisors and the specific truth claims about scientific knowledge in their subject area and whether this was to be understood as accurate, true and reliable. Year One medical students reflected with a scepticism and confusion regarding the truth status of authoritative knowledge with regard to pre-university courses. Their comments related to 'lies' of previous taught scientific teaching, rather than viewing courses as building on simplified knowledge to a deepening appreciation of complexity within the subjects.

> *"Well, I would guess, from a First Year perspective and from what I've experienced that you would start with sort of enjoying the fact that they've told you organised lies in some scientific disciplines, which they have to do at high school."*
>
> Participant F112

> *"I was quite often told, my teachers were very honest with us, saying that what they were teaching us now is not necessarily the truth, because … it's always at the next stage you will learn actually how this works."*
>
> Participant F112 in task group

However, deferential attitudes survived toward University curriculum designers and course lecturers making decisions to what topics should be included in the course.

> *"… I think it's very unprofessional, hugely unprofessional to not go to the lectures that person has taken time out of their busy lives to come and talk to you about something that is important, and they wouldn't put it on the curriculum if it wasn't important. At the end of the day, it's not A levels, it's just not, you know, this is university, this is what people who know more than me, my seniors have said that this is what is important for us to know and I don't have – I'm not old enough to have that right to say 'No, that's not important.' I don't know enough about medicine to say 'That's not important.' If they think it's important then we should go."*
>
> Participant F108 in task group

Participants spoke about the differing opinions of 'expert' voices within the curriculum. This introduced the concepts of competing views and the fallibility of expert resources.

> *"But what I tend to find is that textbook definitions and ways in which it says, OK, it should present, don't always tend to be what you actually see in the hospital. It's often very different to what you actually experience, which can be a bit confusing, 'cause obviously you've read one thing and then you experience something completely different…"*
>
> Participant M305

For one first year medical student this was a source of anxiety.

> *"… they* [faculty] *contradict each other in some sources and it causes confusion."*
>
> Female participant from task group 24 Oct

Medical students were more likely to link fallibility of authoritative knowledge to differing expert opinions, rather than an inherent uncertainty of scientific knowledge.

Some non-clinical faculty expressed concerns that at the medical school there seemed a perception of a hierarchy of authoritative knowledge by medical students, which was biased towards clinical faculty members.

" I think it's this thing of credible source of information… And there's a sort of culture, really, that medics tend to [sighs], it's almost like there's a hierarchy, I suppose, that they have a sense that they will have more credibility if the person teaching them is also a medic."

Participant FAF03

5.5. Theme 2: THE NATURE OF MEDICINE

In this theme participants talked about medicine as a perceived scientific discipline, and what might make medicine scientific. Without exception participants described medicine as a marriage of both art and science. Medical student participants described 'artistry' within medicine as a sense of skill mastery and using interpretative skills with the formation of judgements and decision making in clinical situations.

5.5.1. Medicine As 'Scientific'

When considering the nature of medicine all medical students expressed a firm belief that medicine was culturally perceived as scientific.

"I think, when anyone thinks medicine they automatically think of science, so I think it's just a natural link."

Participant F114 in task group

Medical students in Year One typically associated science within medicine as something that was conventionally received, but were also keen to associate the practice of medicine as an 'art,' such as given in explaining decision making during clinical assessments and procedures.

"…So yeah, you can't have like a robot carrying out a consultation. Obviously as technology improves it, it might go towards – I don't know, if technology improves it, it goes more towards science 'cause I guess it would get more clear-cut, wouldn't it? As you understand more about the body …"

"I'd say anaesthetics is quite arty isn't it?"

"Yeah".

"'Cause, it's like they say, you've got to do so much physics before it and you've also got to assess, like, the pathology of the patient and the procedure they're having and the time. And that seems like quite an arty kind of – weighing up balls kind of job."

Participants M104 and M105 in task group

There was a sense that artistry within medicine encompassed mastery of skills, such as interpersonal relationships or eliciting patients' stories and feelings, and that this was associated with notions of creativity.

"Well it is something that gets said, isn't it, that it is an art as well, and I think that's the clinical side of it where it's eliciting a history, building a rapport with a patient…"

Participant M308.

However, also amongst a minority of Year Three medical student participants there was consideration of a creative component within scientific thinking. This was described as a way of exploring new possibilities when encountering uncertainty and in acknowledging that emotional engagement was integral to a scientific process that was creative.

"I think without creative thinking the science is going to stagnate a bit. Because if you're just going for the most obvious routes you're missing out on a whole range of opportunities which, if you just think outside the box a little bit you could come up with something really unique which actually could work really well."

Participant M303

5.5.2. Identifying The Differing Types Of Uncertainty Within Medicine

As part of defining the nature of medicine participants talked about medical uncertainty as a key characteristic of the discipline. Participants spoke about their experiences of encountering medical uncertainty. Year One medical students typically recognised that practicing medicine meant they would encounter situations where they felt uncertain of a diagnosis. They expressed views that curriculum text books were most likely to present cases in terms of certainty but that faculty expressed views that indicated fluid and changing opinions. For some Year Ones there was a mental adjustment to be conquered in hitherto seeing the world in certainties to that of increasing uncertainty in the study of medicine.

> *"I'm interested in emergency medicine and I know that has so much uncertainty, so I'm kind of learning to accept that answers are not always going to be there, and it's part of the challenge I guess, not always knowing what's right... I would say textbooks are a bit more black and white, I think in our lectures when something new arises and they kind of say opinions are changing about this."*
>
> Participant F107

> *"… a big thing that I've come to realise with medicine is that you're not going to be sure a hundred percent of the time… it's going to be difficult for us because if you're students who've had good grades and have always been 'I know the answer to this', it's going to be a difficult step down from that to 'I'm not actually going to know the answers… "*
>
> Female participant from task group 24 Oct

Medical students identified clinical or diagnostic uncertainty as a type of medical uncertainty. This related to uncertainty about the diagnosis and cause of illness. For Year One and Year Three students this was generally accepted as expected within medicine.

> *"How can you ever be sure? It's one of those – you can be 99% certain of a diagnosis, or at least it seems to me with everything we've learned so far, 'cause short of it being like blindingly obvious, like, in front of you, nothing else presents that way, it's always a bit of a gambling game, isn't it.'"*
>
> Male participant from task group 31 Oct

> *"I think even with that, with every patient, no one ever is a textbook definition of the presentation… they're never the textbook definitions that you learn or you hear about."*
>
> Participant F306

Participants talked about the limitations of their knowledge in relation to scientific knowledge in medicine as a type of medical uncertainty. Two medical students singled out scientific knowledge informing pharmacology as incomplete and uncertain. This was identified as incomplete knowledge and uncertainty as medical knowledge keeps changing in light of new 'evidence', rather than uncertainty as something inherent to the nature of scientific knowledge in itself. For the Year One medical student incomplete scientific knowledge was a source of concern for their future practice.

> *"…we're very aware of the fact that people are prescribing drugs that if you say 'Oh well, so how does it work in fixing this disease?' and they say 'Well, we don't know, we just know it does.' So even now there'll be people prescribing – they'll be in NICE guidelines, people prescribing drugs as per guidelines, not actually knowing why it works, how it works, it just does, and that's – there's quite a lot of that. And it's quite nerve-racking going in prescribing someone a drug when you don't know how – as a scientist and a doctor – how that works."*
>
> Participant F108

> *" I was on a stroke week recently and they were saying that currently they use thrombolysis if the patient's got in within a certain time limit and they have a certain kind of stroke, but they were also saying that the evidence behind it isn't completely solid, and so it seems to help but they're not entirely certain as to whether it's the correct treatment that they should be using."*
>
> Participant M303

Regarding the uncertainty of scientific knowledge one faculty member expressed a view that reliance upon clinical tests to reduce diagnostic uncertainty could be counterproductive (and could put patients at risk). This view argued against a misconception expressed by clinicians interviewed by Farnan et al (2008) that more scientific data reduced clinical uncertainty and therefore made patient care safer.

> *"*[on managing diagnostic uncertainty]…of*ten their uncertainty pushes them to order yet another test, yet another test. And because there's always error in any test all they're doing*

is compounding the errors, and so getting their head around that concept – is it actually sensible to order another test? What is it going to change about your decision?"

Participant FAF03

Timmermans and Angell (2001) reported that medical education research since the 1950s consistently identified uncertainty of a medical knowledge base as a source of anxiety for medical students.

However, most medical student participants expressed feelings of being secure with their limited knowledge of medicine and that their knowledge may always be partial. Where they had feelings of being ill at ease with their limited knowledge of medicine, medical students sought to find alternative solutions to increase their knowledge base, such as through membership of medical societies.

Some Year One medical students reported in their interviews that a career in medicine meant life-long learning and that at medical school it was impossible to know everything.

"I think at the beginning…we thought we were expected to learn everything there was to learn now. But I think we have to sort of take a step back and say, you know, hey, we're here for five years, and even some GPs don't know about these kind of things, so I think it's important to keep that in mind."

Participant M102

By Year Three medical students equated being open about the limits of their knowledge with professionalism and patient safety.

"I think in practice that sometimes it's quite important to be able to acknowledge that actually it's not safe for you to be able to make a decision. And it's something that you need to go away and look at that and look for advice and I think that being encouraged to answer everything all the time is actually dangerous."

Participant M308

One Year Three medical student identified the tension between generalisable guidelines for whole population groups and the individual treatment needs of individual patients. For them this was a type of both scientific knowledge uncertainty and diagnostic medical uncertainty, which drove and informed progressive individualised medicine.

> *"… it's a strength of doctors to be able when you perhaps need to deviate from those guidelines, and I don't think that's always emphasised enough… we had one lecture… he was explaining about guidelines and he was saying guidelines aren't rules* [and] *that you don't get innovation unless you're thinking about things in a sensible fashion…."*
>
> Participant M308

Just one of the Year Three medical students identified process-based organisational uncertainty as a type of uncertainty within medicine. This was with regard to professional work environment uncertainty in terms of professional etiquette and relational uncertainty as interpersonal communication and being unclear about organisational protocols. This uncertainty is a reflection of doctors (and medical students) facing challenges of changing work rotations on a regular basis.

> *"I was just in resus and there was a lady and I was there on my own, she had an oxygen mask on, she had significant left sided weakness, we were trying to get a cannula, take some blood, we couldn't find a vein at all, so the doctor had sort of scuttled off and left me with her. She'd vomited a few times and she started to vomit again. Now, on the face of it, someone's vomiting, it's not rocket science, really, but am I able – should I sit her up to do this, should I try and roll her, so I take the oxygen mask off, there's a suction thing here… suddenly you feel like a child again, you don't know how to do anything 'cause there's a protocol for it, or is there?' you know, are you going to do the wrong thing?"*
>
> Participant M302

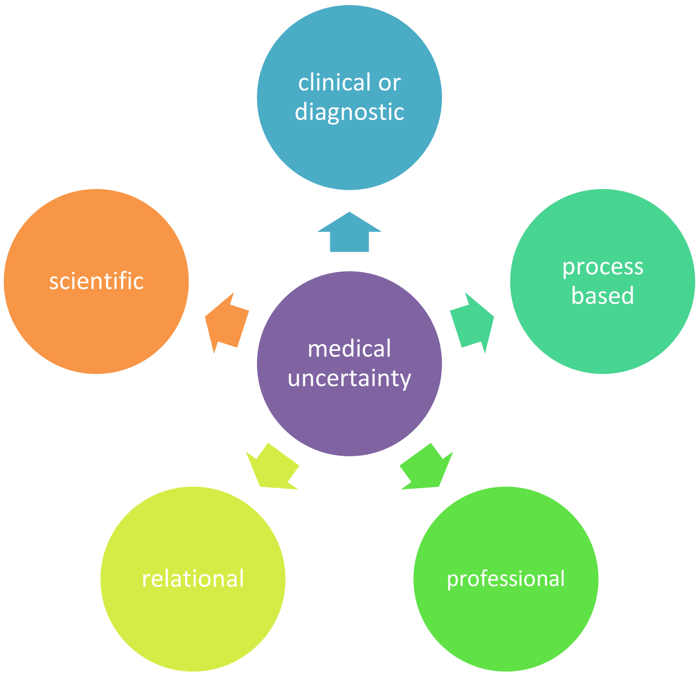


Figure I. Types Of Medical Uncertainty Identified By Participants

In summary, medical students expressed in their interviews the ‘artistry’ aspect of medicine, viewed as communicating with patients or making a clinical diagnosis, as a source of medical uncertainty. They reported that this was inevitable and to be accepted as part of living with uncertainty as a doctor. Medical students did not necessarily hold beliefs that increased exposure to medical uncertainty in the form of clinical decision making would lessen uncertainty in clinical decision making. There was a general expressed acceptance that this type of uncertainty as accepted and ‘normalised’. However, medical students were more likely to express perceived uncertainty of scientific knowledge informing medicine as something to be resolved, holding on to beliefs about the progress of scientific thought being able managing problems of uncertainty of scientific knowledge.

5.5.3. Introducing Complexity And Uncertainty In Medicine Into The Curriculum

Participants discussed their experiences of clinical placements occurring from the first term in the first year of the BMBS course. Faculty commented on early clinical placements helping to contextualise knowledge and helped to introduce clinical and diagnostic uncertainty into the curriculum. They thought early introduction to clinical presentations better prepared medical students for real life medical complexity and uncertainty than traditional curricula, when clinical placements occurred from year three onward in the course. Brennan et al (ibid) agree that early clinical placements for medical students helped with the perceived management of clinical uncertainty through repeated exposure to this type of medical uncertainty.

> *"But if you haven't been in that environment because you've not had a clinical exposure, this is my perception, then you can't know how important some areas are because it's not the path you've trod…having trained myself in a reasonably sort of lecture heavy, basic sciences, pre-clinical, you know, and then suddenly out to see patients, I think it is really good to start to come to realised that it's not quite as black and white as it seems… when the students are going out to GP placements, they see patients who are ever so complicated and things that can't be sorted out.. But I think it's also good that they have somewhere where they can discuss that or why a doctor might have done something they think is wrong, you know, why someone might give antibiotics when someone's got a sore throat, even though it might not be necessary. All those sorts of things, it's good for them to be able to tease it through before they actually have a bit more contact with patients."*
>
> Participant FBF03

Year Three medical students gave many examples of clinicians and academics role modelling uncertainty in knowledge in their areas of expertise.

> *"I think there was a consultant, a dementia consultant I saw and he said there's still so much research to be done in Alzheimer's they don't really know what happens although there's loads of funding gone into it, but he was saying how it's really, really uncertain, just because they don't know the cause of it or how it works."*
>
> Participant F305

Medical students spoke about exams and other types of assessments they had experienced on the course. In term one of year one first year medical students had little knowledge and experience of assessments at the medical school as task groups took place in the first term, before their first assessment. For those first year medical students, being subsequently interviewed during the second term of the academic year, these students were coming to terms with the assessment process that differed from A levels in its style and expectations around incompleteness of knowledge.

> *"… but it's just having the questions come on the screen that you won't know, I think that's quite a daunting experience because you're not meant to know everything…like in school you have A level exams but you're revised everything and you've done revision, whereas for the AMK* [progress test of Applied Medical knowledge] *no matter how much you do it's never going to be able to fulfil – to answer all those questions."*
>
> Participant F114 in task group

In the second term of the course, Year One medical students had experienced two progress tests, for some there was realisation that the progress test was a test of applied medical knowledge and underpinning medical science. One student expressed the view that the test was a good design, in preparing medical students for critical thinking in an uncertain clinical environment. Therefore, in this way the design of the progress test reflected the reality of a clinical environment and decision making that could be uncertain, complex and used a problem solving approach.

> "[The progress test] *First it's preparing us for Year Five, that's what we have to know at the end of Year Five, we're getting used to this being thrown in the deep end where there's a whole lot of unknown, that's what happens when we're doctors [laughs]! So and then it gets us mentally prepared: something unknown, can we think clearly and slowly?...The second thing is it's everything is scenario based and it goes along with my way of thinking that there's always pieces, many pieces to a puzzle and they all give all these little clues. And the other thing, the third thing I would say I like about the AMK is that because it doesn't ask specifically anatomy and physiology… we have to use our creative, our critical thinking, our creative minds to be able to come to a decision."*
>
> Participant M108

Many faculty reported in their interviews that the progress test modelled real life medical uncertainty. They expressed views that the design of the progress test instilled training for students to admit the limits to their knowledge. Most faculty reported that the design of the progress test aided in developing a rhetoric of clinical uncertainty.

> *" And I quite like the fact that there's that 'Don't know' option in the AMK because if you're facing a complex clinical decision and you genuinely don't know, you don't just take a wild guess, you somehow get more data, you know, you do more investigations, you refer to a specialist or something, and I think that whole concept of 'Don't know' and being able to admit you don't know and you need more information or you need to ask somebody else, you know, I think is quite important."*
>
> Participant FAM02

> "[medical uncertainty] *I think it's an important thing for students to grasp… And single best answer questions, when they are written ideally, offer five answers which are all plausible and in a clinical situation one option may be the most likely to be the diagnosis or the best treatment, but others potentially could be. And students sometimes struggle to grasp it. Well, it might be option B but option C is the correct one. But actually that's what clinical medicine is like and there are times when somebody comes in with abdominal pain or a headache or whatever and you look at the background, examination history, what investigations you have and you've said 'I think the most likely cause is X, Y or Z', but actually it turns out that in that particular case it's not, even though statistically you'd go back and say 'Well I still think it would have been the most likely to have been kidney stones' or whatever, and actually it turns out it was something else, and that type of exam does help prepare them for the fact that there is uncertainty in what they will face in clinical practice."*
>
> Participant FBM01

Most medical students and faculty expressed hesitation about when they thought the appropriate time to introduce the complexity and uncertainty inherent within medicine in the curriculum was. One Year Three medical student in their interview said that introducing complexity and uncertainty in scientific thought would have been too difficult for students to comprehend prior to university, and needed to develop later.

…"We were taught about – in SATS [statutory assessments in primary education] *its photosynthesis and you learnt about water and carbon dioxide gave you glucose and oxygen, and that was the chemical reaction that took place. Then you got to GCSE* [general certificate of secondary education] *and it was like – those two things might go in the bottom and might come out the top but that is not what happens in any way, shape or form. And I think… so the uncertainty is there… you couldn't teach the sort of high level science, which is uncertain, at that level. I mean, I would not have understood any of it, I would have been completely baffled."*

Participant M306

However, another appreciated an A level science teacher's honesty regarding uncertainty in science that they would encounter at university level learning.

"…my A level teacher was very much like – when you go to university and if you do a Chemistry degree you're not given everything as a fact, you're not given things kind of black or white, you're to think about things and investigate and he had that mind-set that he wanted us to kind of grow from seventeen, eighteen, which I think was really helpful. "

Participant F301

Overwhelmingly faculty expressed views that being comfortable with medical uncertainty for medical students developed in the later stages of the course. Faculty reported there could be a tendency toward less tolerance of uncertainty at the start of Year Three with a move to primarily clinical placements. It was expressed that at this time medical students might crave more 'certainty' when facing the reality of complex medicine.

"… - they're probably watching Casualty, thinking 'I want to be a doctor'. It's all very – portrayed as being very certain, isn't it, there's a diagnosis, there's a treatment, there's a this, there's a that. So I think there's quite a lot of exposure to the certainty of medicine, but actually the reality is not that, you know, in clinical practice...[on transitioning to year three] *you've suddenly got a whole load of more clinical exposure and then you're suddenly realising that not everything's black and white and it's harder than it looks sometimes. So I think that that would probably be quite a natural time to have a wobble, as it were."*

Participant FCF02

There was a view expressed by faculty that the course design of self-directed learning fostered an appreciation from year one of complexity and uncertainty in medicine. However, there was a perception that uncertainty in clinical presentations was easier to grasp from an early stage of the course, but that scientific uncertainty in medical knowledge was more complex to understand and would develop in the later stages of the course.

"…I think with drug trial evidence and stuff it's always spun in a particular way, but to be able to be critical and take it apart and figure out what actually it has shown, and understand whole new classes of drugs. 'Cause during their time as doctors there's going to be loads of new classes of drugs that come out that we can't even anticipate now, but I think it's important that they have that ability to interpret evidence, complicated evidence from complicated science later on. And I think Year One and Two it's not really relevant and it's too difficult, really."

Participant FAF02

"So maybe that's the argument for living with uncertainty is that actually it is tough at eighteen, but actually if you start at eighteen by the time you get to Year Four and twenty two, twenty three then you're in a better position to live with uncertainty."

Participant FBM02

5.6. Theme 3: EXPERIENCES OF EDUCATION

Medical students talked about their experiences of education prior to entry into medical school and their experiences of learning whilst on the BMBS course. Faculty talked about their experiences teaching the BMBS curriculum at PCMD/UEMS and how this compared with their experiences of teaching at other medical schools. Medically-qualified faculty also talked about their experiences of receiving medical students to their place of work on medical student clinical placements. Theme 3 explored what curriculum factors facilitated or inhibited medical students' epistemological development, at key transitions, such as through informal and hidden curriculum factors. The key sub-themes from all participants (medical students and faculty) were with regard to how medical students coped with and adapted to an expectation of developing independent learning skills required at the University, managing depth and breadth of learning in the course and perceptions regarding the relative valuing of sciences included in the course curriculum.

5.6.1. Self–Directed Learning And The Extent This Engenders Growth In Independence As A Learner

Participants talked about *self-directed learning* (SDL); where the individual takes the initiative and the responsibility for what occurs, to select and manage their own learning. SDL has been described in a literature review of medical education as ill-defined (Ainoda et al, 2005). However, definitions within medical education curricula include concepts such as

- consciousness of the need and acceptance of the responsibility for evaluation of practice in the light of changing understanding;
- ability to identify deficiencies in own knowledge, skills and attitudes;
- motivation to generate a learning programme to address deficiencies, including finding and using the best evidence;
- having the skills to identify, access and use resources wisely and efficiently;
- ability to evaluate learning efforts, including resources used, and the effects on practice,
- commitment to repeating the cycle with each patient and clinical situation. (Miflin et al, 2000)

Medical students and faculty talked about self-directed learning as a conception of learning. Faculty observed that the skills of SDL could take time to develop but thought that these were successfully obtained by medical students over the duration of the course. Faculty acknowledged that for first year students SDL could be challenging as it was a different approach to learning they would have experienced pre-university and this approach meant that students faced uncertainty when planning the content of learning.

> *"I only see the First Years as academic tutees… it takes them until the end of the year, I think, to have really worked out how they're going to structure their learning. So they find it very difficult at the beginning, because you've got that whole change to problem-based type learning, self-directed learning, they find it very difficult to know how much detail to go into and how to spend their time...So you see quite a change as the year goes on."*
>
> Participant FBF02

> *"Because if you've been spoon fed or taught in a certain way and you've not had that constructivism approach, then how can you be expected to just suddenly adopt – I'll create my own learning outcomes? Because normally they're used to ten year or whatever of school from, you know, four to eighteen, six to eighteen, they've been told – these are the learning outcomes, this is what you need to pass this exam...Whereas, of course, that's not the case when we ask them to create their own learning objectives in small group facilitation or in PBL."*
>
> Participant FBM02

For medical students there was expressed realisation that the step up to university learning demanded periods of flexible and extended independent learning using a range of teaching and learning resources, which may be potentially open-ended and there may be no right answer to choosing appropriate resources to use. The vast content of resources available to them had made them realise that they needed to develop strategies for choosing information sources, although at this stage this was undeveloped. Year One medical students expressed the most anxiety regarding SDL and the challenges of learning these skills. However, as the course developed these expressions of anxiety diminished.

> *"Whereas here you've got, like, fifty textbooks that you have to learn and internet sources and what-have-you so I think I had to change my, like, approach to how I learn the material here."*
>
> Participant M104

One Year Three medical student recalled the challenging transition at medical school and being expected to create their own learning goals.

> "It was a shock in first year because I think it's very easy to feel out of your depth because… there's not an awful lot of guidance on what you should be revising, and each group in PBL does something different and that can be quite overwhelming, but you get used to it, and you realise how you learn."
>
> Participant F301

Those that had come to medical school with previous experience of university learning, typically found the transition to Year One self-directed learning less daunting.

> *"Well, yeah, personally for me, because I've already had a year of university learning, it's far more independent, it's not come as a massive shock."*
>
> Participant M105

Some participants chose to apply to the medical school for its curriculum approach of small group and problem based learning (PBL), feeling that this engendered independent learning skills. Even at the stage of the first term in the course medical Year One students were verbalising that they were adapting to the demands of the self-directed learning approach of the medical school. Year Three students said they generally used SDL to positively manage their own gaps in knowledge or develop depth and richness of knowledge.

> *"I just found the main difference is that I can learn some of the things I want to more, while still covering what I need to know for the course, which is kind of like encouraged by the PBL questions…I think we're, like, learning the skills of, like, consolidating and, like, clarifying which material is, like, most relevant to what we're learning."*
>
> Participant M104

> *" I'm part of the Obs Gynae Society in the uni…I attend the lectures or I'm involved within it because of the interest in it and I just want to learn more rather than I don't feel that we're*

getting enough from the placement itself, if that makes sense. There's definitely the opportunity there and you can definitely do the work yourself…"

Participant F306

There was a common sentiment expressed from Year Three medical students that over the course they had grown in confidence in taking responsibility for their own learning.

"I think that once you've picked up on your kind of areas that you're lacking in, you can go away and read up on them and you can catch up… Particularly in Third Year it's just, I think, the place for that because you get to see sort of much more dynamically and structure your learning much more¸ because I found that PBL almost could be a bit restricting… in that you had a very specific set of questions and actually perhaps if your knowledge is lacking in certain areas it's quite useful to go back and consolidate things."

Participant M308

5.6.2. Perceptions Of The Depth Of Learning Required In The Course

Participants reflected on the structure and learning requirements of the BMBS curriculum. Findings suggested that Year One medical students struggled with gauging the depth of learning required at medical school compared with instruction at pre-university institutions. There were comments expressing anxiety of how much depth self-study needed to go into. These students thought a more structured curriculum would help in this respect and some were unsure when to approach lecturers for support and guidance. The concerns expressed regarding the perceived depth of learning required on the course posed a fundamental challenge for medical student self-directed learning skills and confidence in the early stages of the course.

"You need like a specification. That's what you had at A levels – this is what you need to know. I wish we had that now, it would make life so much easier, but we don't, so a lot of the time I just think 'How much depth shall I do on this.' I either do too much or not enough."

Participant F102

"…that has been recurring in PBL sessions. You make a question but then you've got to research it and you think well how much depth do we have to go into? If I wanted to you could write thousands of words on the triggers on asthma, but do you – or do you want a list, you know, how far do you go?... I think all facilitators have a list of things that the group has to go through, but I think it's down to the group to sort of figure out."

Participant M102

For one first year medical student there was often a realisation and a changing perception about the skills independent self-directed learning brought about in developing deeper thinking, compared with the learning requirements pre-university, which they thought were linked to narrow curriculum requirements.

"…it's always that over your head, like, what do I actually need to know, that's never very clear to you so it's sort of entirely up to you what depth you want to go into... you can go off and learn what you want and what depth you want. Obviously it's more work in that respect, and it's a bit more, like, overwhelming, but I don't know, I sort of like it, you feel more like an academic than just somebody that's churning out, like, just to pass your exams."

Participant M105

In a paper by Mattick and Knight (2007), writing on the achievement of high-quality learning in medical education curricula design, which explored medical student perceptions of learning and study approaches, they identified a deep approach to studying as synonymous with high-quality learning. They also identified medical student anxiety regarding the quantity of perceived information required to be absorbed on a medical degree course as a potential barrier to the achievement of high-quality learning.

5.6.3. Breadth Of Topics Covered In The Course

Faculty commented on the curriculum needing to satisfy the GMC curricula requirements and the challenges for curriculum designers of breadth within a contested curriculum. There was an acceptance that the course needed to be relevant to the application of clinical practice, assessing the level of relevant knowledge was the challenge within the course topic coverage. Faculty expressed comments that the curriculum content had changed in recent years due to high profile incidents regarding professionalism, which commanded higher profile in the current curriculum.

> *"It's tricky…the more and more I've looked at the medical curriculum, certainly from the pharmacology point of view… there's stuff that… that you think 'Oh, that's really good, they should know that' and then you think, but when you actually go back does a clinician really need to know, or does an F1 doctor really need to know this? And you go 'I'm not convinced they necessarily do.'"*
>
> Participant FAM01

> *"And now we've gone to outcomes based Medicine it is about competencies and tick boxes rather than knowledge for knowledge sake or…research and scholarship."*
>
> Participant FBM02

Some Year Three students commented on clinical placements being limited in time and a perceived insufficiency for in-depth learning to take place.

> *"I would like it to be longer… A week isn't enough, but I also understand that at this stage they don't want you to know everything, so in a week you get to experience what's common in that field, and in Year 3 I think what they want us to see is, you know, the really common stuff which you can in the four days."*
>
> Participant F303

Faculty commented on clinical experience providing a valuable socialisation into medicine, even if depth of learning was hard to achieve whilst on short clinical placements.

> *"I talk about how the carousel spins too fast really, I think, in Year Three, but the students love the breadth of the course and the fact that it's very equitable 'cause everybody gets the same sort of exposures, so the students like that but the teachers find it difficult to have a*

new group every single week, they don't feel they build relations and of course part of medical education is a socialising into the profession."

Participant FBF01

One first year student commented that they initially found it difficult to see how aspects of the curriculum fitted together and that the curriculum felt disjointed. However, with more experiences of topics they were able to express a wider appreciation of curriculum aims and how learning connected.

"Cause you've got so many [sighs] 'cause you've got LSRC [Life Sciences Resource Centre] *which is like the basic principles and all these different other subsections that don't quite link together, so it's much harder to find the connections and learn it. But it's getting a little bit easier because current case units are linking to old ones, which makes that easier. But in terms of when we first started I found that really difficult, thinking 'Well, what we're doing in clinical skills like, for example, I don't know, thyroid examination, it didn't fit with our case unit, that was on young children. It was like – just trying to squeeze it in anywhere, it felt like. Yeah, I think it's going well. Seeing the links."*

Participant F102

5.6.4. Perceived Less Structure As The Course Developed

Participants spoke about the nature of curricula they had experienced previously. Participants talked about structured curricula at A level, designed around specific subject areas, related to exams and assessment processes.

Medical students described their approach to learning for assessments at A level as directed by teaching staff focussing on a prescriptive and limited content required to succeed in the exam.

"At my sixth form we were very much spoon fed into making sure you got the grades that you needed to get, so they pretty much went above and beyond their call of duty to sort of hand you what you needed."

Participant F306

Medical students described A level sciences courses as designed and structured specifically to test recall of text books in the exams.

> *" – ultimately the* [science] *A levels were just epic quizzes on what was in the textbook, they weren't going to ask you much more other than what was in the textbook."*
>
> Participant M307

In Year One of the BMBS curriculum medical students said they struggled with a seemingly less structured curriculum, compared with school and college.

> *"… in one way you have to catch on to determining how much you're supposed to know or how much you're not supposed to know and there is actually one thing that I think would help with the curriculum here is that there to be – I know we have a study guide, we do, but for there to be an even broader term study guide of maybe just a few pages, maybe more like an outline, 'Should be proficient in this system, you should be proficient in this topic area."*
>
> Participant M108

> "…at the beginning it was a bit difficult, sort of, just trying to work out which one to use [textbook] and just sort of that kind of thing…especially in First Year… I think especially if you've just come from school. …for example, the structure that you're used to suddenly had disappeared. And it was a really big shock change. I think a little bit more structure would have been helpful."
>
> Participant F302

However, by the third year, medical students looked back on Years One and Two as having greater structure and more commonalities with pre-university learning than year three, which has primarily clinical placements.

> *"Well, I know as first and second years we sort of were always in university...So in that I really liked that aspect of the course because we were almost sat in classrooms, sat in tables, in rows of tables and science, they were – it was being taught as if they were school lessons, and I actually quite enjoyed that because it wasn't too dissimilar from what I previously … I*

mean, in a way I think the jump from A level to first year university is exactly the same as what we've come from second year to third year. And in a way nothing can prepare you. The best thing to do is to talk to peers …"

Participant M304

The Year Three medical students commented on a perceived lack of syllabus and structure, particularly on ward placements in Year Three. It is suggested by Prince et al (2004) that formal learning in a hospital environment, as experienced by junior doctors, is limited and opportunistic. As such, Year Three medical students' learning in clinical placement was beginning to mirror an authentic type of learning post-graduation. Van de Wiel et al's (2011) interviews with junior doctors found that in the clinical environment hospital doctors reported learning was not usually planned. However, it may be argued that for high quality learning to take place in the clinical work environment, medical education should be "planned, structured and scaffolded" (Brennan et al, 2010).

"… [Years one and two] *gave us a structure that perhaps we don't really experience now in clinical teaching, there's not really much of a structure to it. It tends to be you learn what happens on the day, there's no actual curriculum that seems to be followed."*

Participant M305

" I certainly haven't been aware of a consultant who's ever had a learning plan for us. There's been quite a few, they've had – and we meet up and start the week and they say 'I want you to see this, this and this' and if they've worked a teaching session into the timetable with the consultant, then quite often you'll be there and they will ask you what you want to learn about or they'll say 'We're going to do this' and they'll teach you a bit about it then as you ask questions they'll probably say, you know 'Fine, that's your job for Friday, go away and learn that and', you know 'You'll present your patient and you'll tell me about this."

Participant M306

Faculty talked about students' perceptions of an ill-defined curriculum and lack of structure within. Faculty commented that their role was in fostering independent learning but also to provide pointers to core knowledge in a loosely defined curriculum. This meant striking a balance between a steered curriculum and independent learning opportunities.

> *"Some of the best opportunities you might come across clinically will occur in Pathway weeks when you're doing something else, so you might have a very interesting cardiac patient when you're doing gynaecology, who comes in just incidentally has aortic stenosis or whatever it might be. So you really have to stress to the students that they have to learn what they see in front of them and be always ready and willing to branch out slightly from what should be the core theme of that week or that day or whatever it might be, to learn from what's there… It's very easy for students potentially to go wandering off and miss the overall point when they have no direction or no guidance at all, and that's my biggest concern about e-learning or, indeed, self-directed learning overall. And if it's totally unsteered, it's possible for them to waste a lot of time and miss fundamental points."*
>
> Participant FBM01

One Year Three student in their interview expressed the view that a perceived lack of course structure was more to do with university level learning than the specific course chosen. They represented the view expressed by many in year three of the course that the medical school curriculum was designed as a preparation for life-long learning, rather than short term goals of knowledge recall to pass exams.

> "[reflecting on learning during a first degree course]… *at the time I remember I was like 'But where's my – where's the curriculum? What do I learn? Which textbook do I have to memorise?' So no, I wasn't prepared for it at all. But I think that's university in general, 'cause even looking at – with my peers doing other degrees, you don't get told 'Oh, this is what you have to learn.' But you do get over it…Yeah, I think now that, now into third year we're really used to not having structure and not knowing what kind of direction to go in."*
>
> Participant F303

In summary, medical students discussed the formal and informal curriculum, with Year One medical students typically expressing views that the structure of the curriculum lacked structure and scaffolding compared with pre-university learning. This was a source of anxiety due to the significant transitional change. The Year Three medical students also typically said the transition from Year Two to Year Three, with mostly clinical placements, provided less structure within the curriculum than the foundation two years. They commented that in Years One and Two there seemed more structure compared with Year Three and asked for more scaffolding to be available, such as in longer clinical placements to build essential learning relationships with clinical staff. However, the levels of expressed anxiety for Year Three medical students on course structure were typically lower than for Year One medical students. Faculty commented that less structure to learning when this took place in the clinical environment was authentic to the nature of medicine and learning as qualified professional clinicians embarking on life-long learning (see Figure J for summary of themes regarding perceptions of course structure). The course design was intended to introduce challenges for medical students to self-assess the depth of learning required, a skill they would need as qualified clinicians. Faculty said that they saw their role in being mindful of providing structure for learning opportunities but preparing medical students and nurturing the skills of independent learning as qualified doctors.

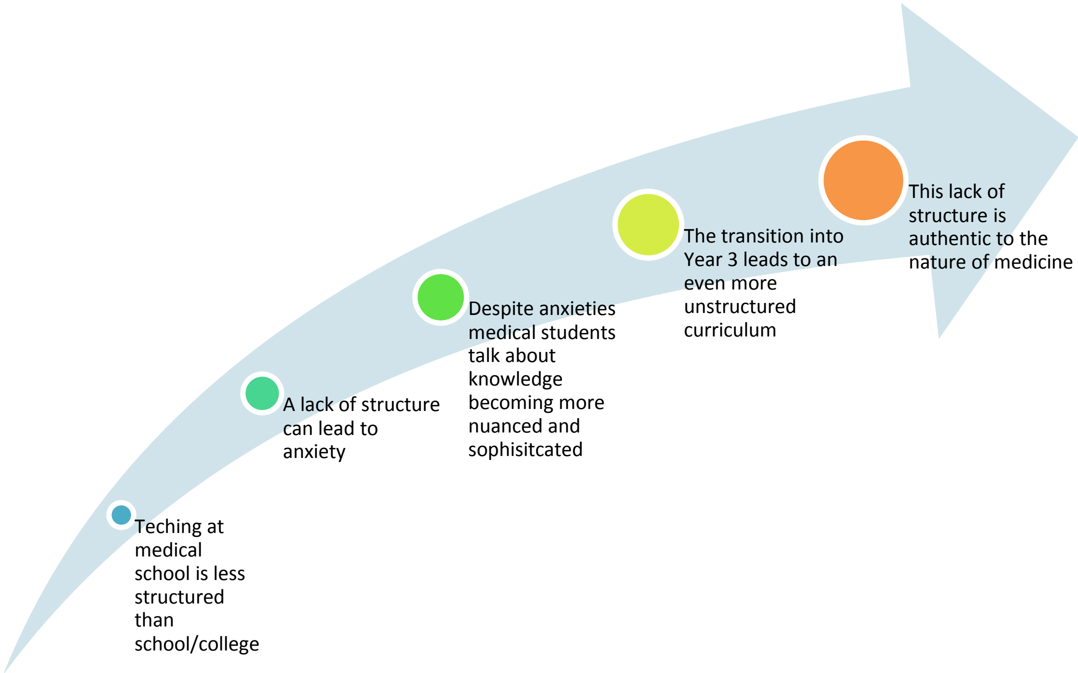


Figure J. Summary of 5.6.4. Medical Students Perceiving Less Structure As The Course Develops

5.6.5. Participant Reflections On The Relative Valuing Of The Sciences Pre-Medical School Entry

Medical students shared a common perception that maths, biology, chemistry and physics were sciences. Many first year medical students said that they viewed biology of greater relevance and applicability to medicine than the required chemistry A level for entry into medical school.

> *"Maths is probably the most clear-cut science, there's not really much debate, it's just learning formulas and algebra and things like that"*.
>
> Participant M104

> *"Well, I guess what I found funny was that you don't need biology to get into medical school but you need chemistry, but I've found that biology's been by far the most useful, just like basic knowledge of, like, the heart and the lungs which you do a bit at A level, you use it all the time here and I just don't get why anyone who wants to do medicine anyway, wouldn't want to do it. Chemistry, that's the one they had so much emphasis on at A level and I just haven't used it at all really here. "*
>
> Participant F106 in task group

There were a minority of voices expressing viewpoints that the social sciences shared a critical thinking approach in common with the basic sciences and were good as preparation for entry into medical school.

> *"Well, certainly I think* [having geography A level] *it's given me a better understanding of public health and sort of more – the spread of disease, population and also environmental factors, and so, you know, an awareness that altitude, you know, will affect your malaria rates because the mosquitos don't fly that high and things like that. And Medicine is very much science meets people, and geography is the study of a global population, so …."*
>
> Participant M306

5.6.6. Perceptions Of The Relative Valuing Of Topics At Medical School In Relation To Medical Knowledge, In Particular Scientific Knowledge

Medical students talked about their own perceptions regarding the importance of curriculum subjects, in terms of relevance to medicine. Interview conversations exposed the influence of the ‘hidden’ curriculum’s influence on these views held. Year One medical students mainly associated bio-sciences with medicine and saw less relevance of the social sciences and humanities to medicine. Year One medical students viewed social sciences either as ‘common sense’ and therefore a skill to be assimilated on clinical placements or difficult research subjects. Some students, notably those with social sciences and humanities backgrounds, expressed views which reasoned that other students would come to appreciate their relevance to medicine as the course progressed. Year Three students expressed views that medicine included relevance with topics wider than a bio-medical perspective. Overall, however, participants expressed views of perceived dominance of bio-sciences within the curriculum. This was accepted as appropriate by most Year One medical students but was more likely to be questioned in terms of appropriate content in terms of learning about medical professionalism and research methods by Year Three medical students.

> *“Yeah, when we initially put the ideas on the board we always try and separate them a bit into biomedical and social and just literally those two things. And it’s always pretty easy to do all the biomedical ones because it’s all, like, anatomy, breathing, and people – that’s generally what people go through first because that’s what they feel is really important. And the social ones always tend to be a bit harder to research because they’re questions like – which groups of people are more prone to, like, risky behaviour, and it’s not something you can just type in and find out.”*
>
> Participant F106

> *“…like, sociology lectures… when they talk about previous papers, like, I can’t really think of a situation in a medical career where I’m going to like have to pinpoint a certain social paper.”*
>
> Participant M104 in task group

"I think people mess around in the psychology lectures and they don't really listen… so the social sciences and the psychology lectures people are – they don't take it very seriously, they think it's not important... they think it's airy fairy social sciences and it's kind of not important."

Participant F108

"… but I think people already think, when it comes to ethics, ethics is kind of, apart from the laws that like, guide the ethics of medicine, it's kind of common sense, that's what most people think… And with psychology I think people find it just confusing, and that's why, like, it's very confusing."

Participant F103

"…when I've been on placement there's varying ethoses within GP practices but quite a lot of them will stress to you the kind of importance of just the social context: the social sort of demographics in their area and how those are potentially much more sort of deleterious to health than any sort of contagion or other kind of quantifiable health problem in the area. And I think there is a bit of detachment between what sort of – the two areas of medicine, like public health/ social/psycho side of it and the much more sciencey, what do we prescribe, which surgeon do we send them to, sort of side of it. "

Participant M308

In their interviews all faculty said that bio-science topics were paramount on the perceived relevance to medicine for medical students, and that anatomy was part of the discourse for what defined a doctor. For faculty the perceived reduced relevance of medical humanities to medicine expressed by some medical students was nothing new.

"I mean, I've had a student in a PBL group of mine say in all seriousness 'Why do we have to learn about public health to be doctors?' and I kind of looked at him in disbelief and, like, well - prevention better than cure, you know, of course you need to know about public health.

But yeah, anything that isn't biomed, so public health, sociology, psychology and medical humanities probably more so than anything, it sinks down their list of priorities. And even within the biomedical sciences, you know, there seems to be a hierarchy of knowledge… it's anatomy first, it's physiology second, it's probably pharmacology third, and then, you know, the things like the molecular biology and the cell biology, they come somewhere next and, you know, then the sociology, the psychology etc. comes bottom of the list and you can see that, even when they're forming questions in their PBL question-setting sessions, it is literally a list in that order… So yeah, there's a definite sense of, you know, science is only biomedical, whereas our definition of science is much broader than that."

Participant FAM02

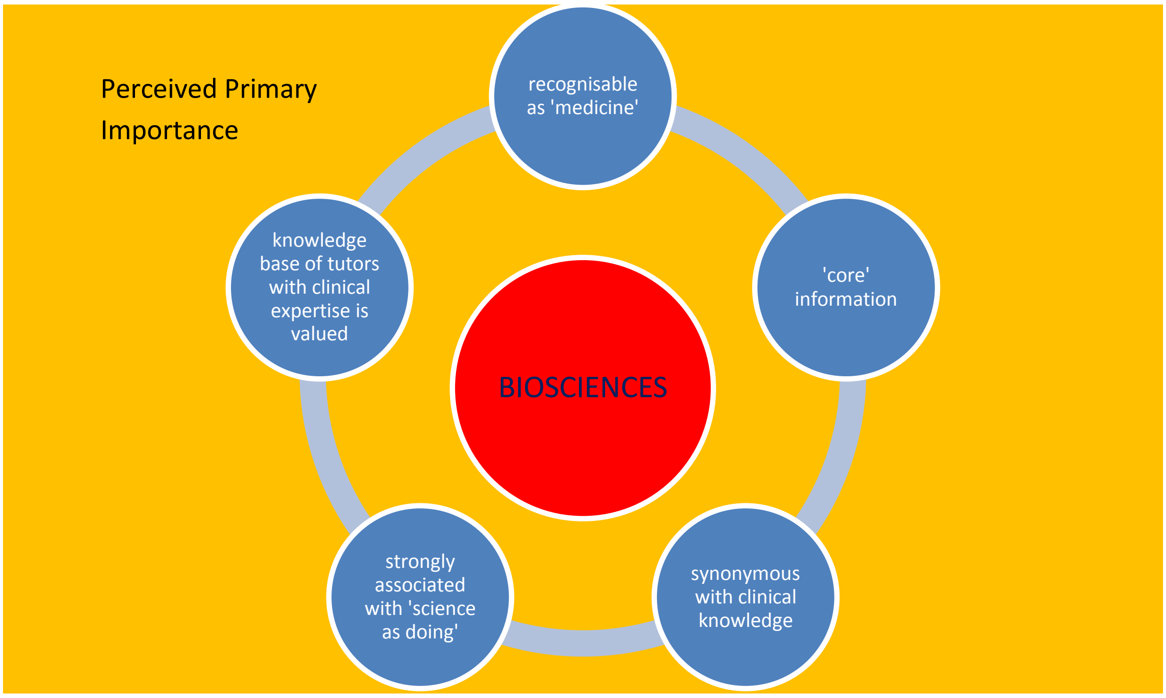
Medical students' views were captured where they perceived if faculty/clinical staff held biases toward/against topics/subject areas, and on what basis this is explained in terms of supporting the development of scientific knowledge in medicine. There was a perception from Year One medical students that the curriculum was biased toward bio-sciences, as the bio-sciences made up the majority of exam and assessment questions. The Year One medical students typically said that they were more likely to concentrate their assessment revision on topics 'valued' in the curriculum.

"But even though there are these psychological and social side in the end of year exam, it's less, like, it's only 10% I think, or something like that, it's smaller compared to the actual science bit."

Participant M111

"…unfortunately when it comes to preparing for end of year test, they mostly focus on physiology, pharmacology… they focus on biosciences more…because a small percentage of questions are from sociology and psychology…'"

Participant FAF04



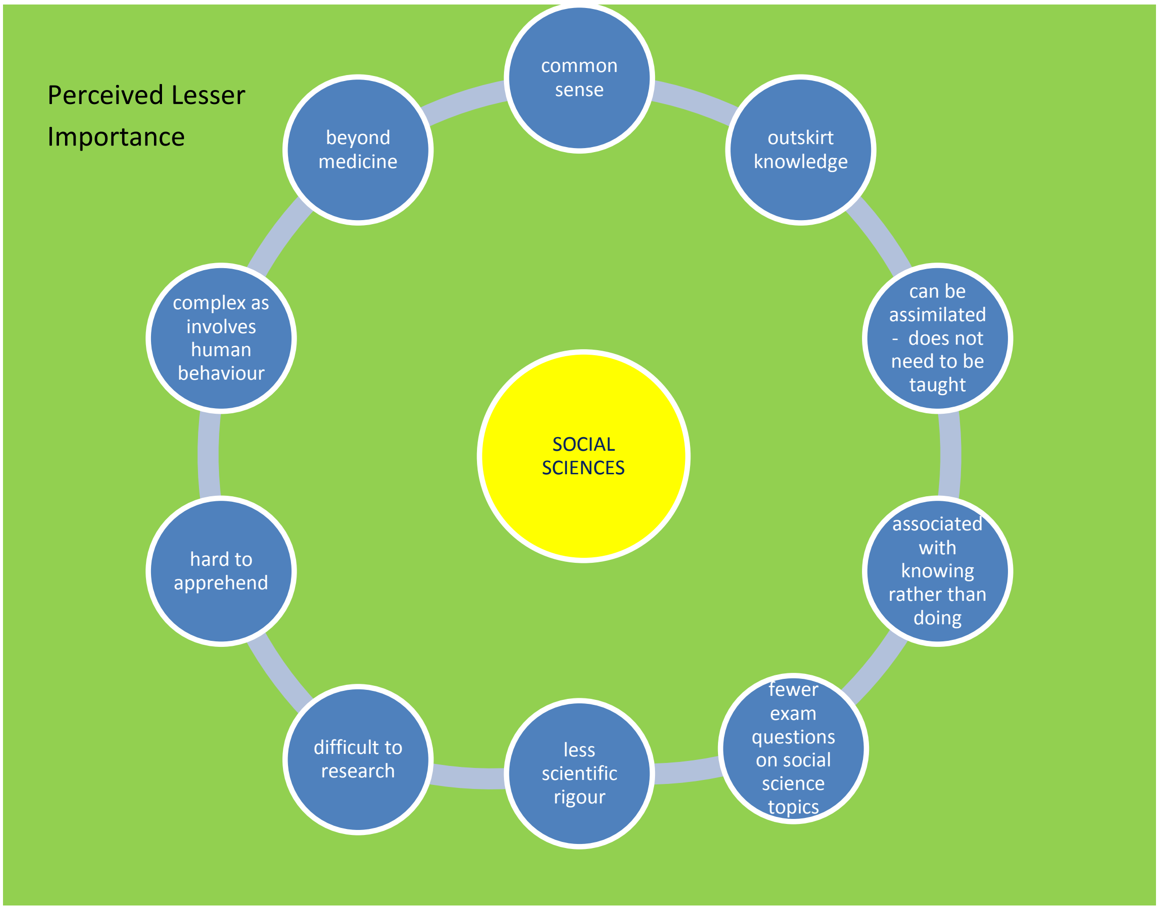


Figure K. Medical Student Relative Valuing Of Topics Within The Curriculum: The Perceived Detachment Between The Bio-sciences And Social Sciences

5.7. Summary Of The Chapter.

In this chapter I have presented the inductive findings emerging from data collected through participant task groups and interviews. With the participants I explored individual personal beliefs and understanding about the nature of scientific knowledge as applied to medicine (in Theme 1, the nature of science and Theme 2, the nature of medicine). This was followed by looking at what participants expressed regarding the BMBS curriculum at the medical school in terms of relative valuing of scientific course content, learning and teaching approaches to developing independence as learners and managing expectations of the breadth and depth of learning required in the course and for future life-long learning (in Theme 3, experiences of education), which ultimately may impact upon medical students' epistemological development.

Chapter 6: Theory-Led Participant Findings

6.1. Introduction To The Chapter

In this chapter I will present my findings of participant personal epistemological views regarding the nature of science in relation to medicine; knowledge and research. The findings will be presented by each participant group and represented by mapping the findings on a quadrant chart; developed using models of personal epistemological development (see section 3.5.8). Where the groups are mapped on the quadrant chart is an indication of where the groups may sit regarding individual beliefs about the nature of scientific knowledge in medicine and conceptual models of personal epistemological development.

6.2. Personal Epistemology Mapping

My four quadrant scatter chart is informed by concepts about the nature of science as socially contingent or socially isolated, on the horizontal axis, with the intersecting vertical axis concerned with the status of truth claims in scientific thought and the certainty of knowledge.

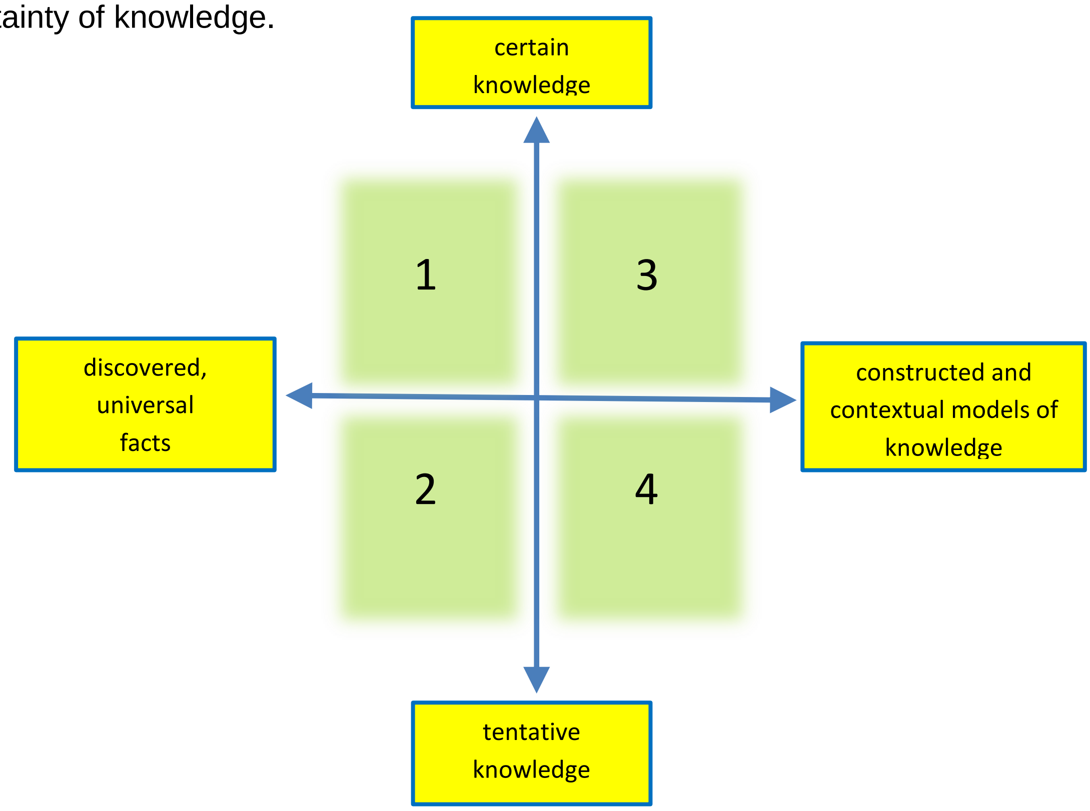


Figure L. Four Quadrant Mapping Of Participant Epistemological Beliefs About The Nature Of Scientific Knowledge In Medicine.

Where participant groups are placed within a quadrant (numbered 1 – 4) may be an indication of participant groups broad personal epistemological positioning regarding the nature of science in relation to knowledge in medicine.

Quadrants 1 and 2 indicate that scientific knowledge is more or less independent of cultural location and sociological structures, in contrast to Quadrants 3 and 4, which suggest that scientific knowledge and scientific processes are interdependent within the cultures where scientists reside and where the scientific research takes place (see Nott & Wellington, 1993). Quadrants 3 and 4 are domains that indicate scientific knowledge is historically, technologically, socially, and culturally conditioned and therefore leads to the development of discourses regarding accepted 'norms' about defining, doing and talking about science, which are open to debate and challenge (see Bakhtin, 1984. Bourdieu, 1979. Fairclough, 1992. Foucault, 1973. Foucault, 1977). Quadrant 4, indicating a contingent or relativist view of the nature of science, does not necessarily mean that groups with this viewpoint hold with an 'anything goes' perspective on scientific methods and approaches. This quadrant encompasses views that scientific approaches are complex and science is complicated. In Quadrant 4 is also the view that the aim of science is to produce further knowledge, rather than to make statements about truth. Quadrants 1 and 2 indicate that beliefs held view science as procedural, rather than creative in process, and that the type of knowledge produced by science, compared to knowledge in other disciplines (such as art) is more objective and unbiased. This view, in turn, suggests that scientists are particularly objective in their scientific endeavour (McComas, 1998). Quadrants 1 and 3 suggest that knowledge is viewed as more fixed and certain compared with Quadrants 2 and 4, where tentativeness and uncertainty is viewed as a characteristic of science. However, in Quadrant 2 it could be that the tentativeness of scientific knowledge is viewed as something that is a temporary state (see King & Kitchener, 1994) due to incompleteness of knowledge or knowledge gaps, that can be overcome through more research or learning. In Quadrants 1 and 3 sit views that science and its methods provide absolute proofs and that evidence accumulated carefully will result in such knowledge. Quadrant 1 indicates a belief that scientific hypotheses develop into theories, that in turn become laws and that scientific laws are absolute. Finally, Quadrants 1 and 2 indicate that general and universal scientific methods exist.

6.3. Year One Medical Students

Year One medical students had the most to say about the nature of science with regard to medicine of all the participant groups because the task groups exercise was specifically set up to explore these questions. In order to inform the development of subsequent semi-structured interview guides, the Year One medical students took part in task group sessions, which involved a card sorting exercise, based around the participants picking out descriptive words, which they thought said something about the nature of scientific knowledge in medicine. Year One medical students tended to strongly perceive Western medicine (where medical doctors and other healthcare professionals treat symptoms and diseases using medicines, radiation, or surgery – synonymous with bio-medicine) as a scientific discipline and the practices of complementary medicine (any of a range of medical therapies that fall beyond the scope of conventional Western medicine but may be used alongside it in the treatment of disease and ill health, such as acupuncture and homeopathy) as non-scientific. They expressed this difference in terms of Western conventional medicine as having a scientific methodological approach. This was explained by these participants by being embedded in the natural sciences (biology, chemistry and physics), which participants associated with having a scientific approach that had the aims of searching for proof and certainty. Year One participants associated scientific proof and certainty with objectivity and validity of scientific results establishing facts. Complementary medicine was considered non-scientific, being perceived as lacking proof, or being concerned with subjective reports of effectiveness via anecdotal evidence, dismissed by participants as too variable and therefore not repeatable in controlled environments, in which to constitute proof and fact. For example;

> *"– a scientific approach I would say is to look at something, it's to take things down to its constituents, like its' very smallest parts without putting your opinions in and try to understand the way they interact… "*
>
> Participant M101 in task group 1

"We had those Seabands, you know, the things for acupuncture. I did some research on it and all the research… said 'Oh yeah, they're really good, they work, they drastically reduce sickness', and then I brought it up in my PBL group and one of my PBL colleagues, peers, said 'Oh no, actually I found a study that said completely the opposite thing' and it was a reputable study! So what do you do in that instance when you've got two reputable studies that contradict one another? What do you do?"

Female participant from task group 24 Oct

"*Whereas with homeopathy… there isn't the trials, there isn't the sort of scientific trial evidence to show that it works all the time, you know…I think the scientific evidence in drugs, compared to sort of homeopathy and acupuncture, that sort of thing, I think it's very separate, two very separate processes, I would say."*

Participant F108

The more an area within medicine was perceived as being influenced by patient perception (e.g. psychology or psychiatry), the more likely the Year One medical students were to describe these branches of medicine as subjective and associated the methods in researching these medical specialities with an unscientific approach. In contrast, these medical students perceived certain specialities of medicine such as radiology as objective and fixed, associating them with a scientific approach; observable phenomena or verifiable by the use of technology. For example;

"I think with anatomy it's, like, quite a clear cut part of the science… I think the science is pretty non-subjective."

Participant M104 in task group

"Cause when I think about the specialties of speech therapy, one of the specialties was, like, head and neck cancer treatments, and I would say that is very scientific, but then on the other hand you might have somebody who works in education or global language delay, stammering and I wouldn't say that's necessarily as scientific…"

Participant F107

"I think it's something, like, you sort of feel like you sort of know that already, it's sort of more like common sense in a way, in terms of sociology, sort of the social side of it…You get papers that are on sort of social and psychological things as well, just behaviour, all that."
Participant M111

Amongst the Year One medical student participants there were a few who were older, entered the medical school via graduate entry or who did humanities/social sciences at college. They typically bucked this trend and had views of approaches to research that were more socially constructed.

"It's funny, actually, 'cause when I was doing A levels, I always thought the basics of chemistry and biology were scientific, but then the way that psychology works at the research and the studies, were more scientific. So you have like, I don't know, like case studies and things like that…[on using theory to inform research]…*so I always found that was much more scientific than what we do in science subjects, so like chemistry and biology, because that was kind of given as fact, do you know what I mean?"*

Participant F102

In terms of personal epistemology, most Year One medical students would sit within Quadrant 1 of the figure I developed to chart the participant beliefs about the nature of scientific knowledge in medicine, where scientific knowledge in medicine was associated with discovered, universal facts and certainty of knowledge.

6.4.Year Three Medical Students

Year Three medical student participants took part in semi-structured interviews. Although they did not do the card sort task group exercise, they seemed very able to articulate their views on the nature of science and its application to medicine. This group epistemologically were typically seeing scientific knowledge as occupying a contested knowledge base. They thought scientific knowledge had an evidence base that was theory led. For these medical students the use of technology to provide scientific evidence, unlike the Year One students, was something that contributed to the socially situated nature of scientific enquiry, rather than a tool to confirm and fix results. They did not typically view technology as synonymous with science, as Year One medical students tended to do. The Year Three students tended to connect the use of technology with the development of scientific discourses around the technology use, affecting how the research was described when written up and subsequently reported upon in the wider culture. This, in turn, affected how further research was approached in terms of culturally approved methods and truth claims. For Year Three medical student participants there was typically a developed understanding of the discipline of medicine as situated in a social context and affected by motivational and professional interests. They generally thought that the BMBS course curriculum structured from Year One onwards had emphasised this.

" I can't remember the saying, but it's like, you know, there's never a fact in science it's just a theory and then certain amounts of evidence will point to that being correct, but you can never say for sure that it's a fact, it's just more evidence out there supports that view than opposes it…Which is why doctors are constantly changing their treatment, changing their understanding of things, because they rely on evidence to sort of decide where, you know, what's going on."

Participant F304

"I think the general public think that science is this sort of definitive, exact thing... And so I know that actually it's quite hard to get a definitive answer out of- you may get it out of one paper or a systematic review will give what-have-you, but it's always, to some extent, an opinion based on – on a layer of evidence and that in itself is often chosen, you know… "

Participant M302

"Yeah, I think so, I think that with science I always thought that it was certain that there are definitions, there is evidence behind whatever topic you're discussing. But a lot of the things I've found out are unconfirmed."

Participant M305

However, although there was a shift in viewing science in medicine as culturally situated and constructed, this group also tended to view good science in terms of epistemological frameworks that were narrowly defined by rules in order to preserve ‘objectivity’ of scientific methods. This group typically reported that they saw this objectivity as a way of differentiating science from art, which was associated with subjectivity and the influence of feelings in producing artistic endeavours. These participants linked feelings and expression of emotions as unscientific.

> *“*[In science] …*there might be two or three ways of looking at something, but that’s about it.”*
>
> Participant F304

> *“Being able to repeat the result is how you prove something scientifically, I suppose…”*
>
> Participant M306

> *“I tend to think science is more objective, there tends to be defined areas for it, whereas with art you think it is more subjective, more due to the person’s own feelings and thoughts about this, whereas with science there tends to be more strict rules and regulations to it, yeah, so in that way you’d consider them as objective and subjective, perhaps on different ends of the scale…”*
>
> Participant M304

Nonetheless, there was one participant who took an alternative view on the role of emotion in science. This participant had studied music at A level and argued that the role of emotion in scientific enquiry was a key part of the creative process of scientific enquiry.

> *“I see with music there’s a lot of maths in it and things like that, so there’s a science element to it, but I’m very aware of the kind of emotional level of the music as well, and I think that’s seeing music as a concept that involves both of those things has helped with the science and seeing – and then seeing science in medicine. I can very easily see the emotional side of it and the science side of it and see how they’re not separate and I think being quite open to*

that through my music has helped with just how I see how science works… I think science, even now isn't like – there's no real like, right or wrong still, and I think with a lot of things that's how you interpret it and how it applies to different things, and I don't see that there's a one-way approach to everything. Be that how you learn a piece of music and how you play it and express it or how you learn a scientific process... which I think is really exciting in science, 'cause it means that every person's different and so you can learn a basic structure but realise that there's so many other things going on that means what's normal for one person is completely different for someone else and I like that kind of – I think that's why I like medicine."

Participant F301

In terms of personal epistemology, most Year Three medical students would sit within Quadrant 3 of the figure charting the participant beliefs about the nature of scientific knowledge in medicine, where models of scientific knowledge in medicine were considered constructed and contextual but also that within these constructs fundamentals of certain knowledge were knowable.

6.5. Very Close Faculty

These participants were heavily involved in the teaching of the BMBS course, mainly with Year One and Year Two medical students in small group learning. The participants typically held PhDs either in the natural sciences or social sciences, typically did not have a medical degree and typically had educational roles at the University. This group typically expressed quite homogeneous personal epistemological views on the nature of science, that scientific knowledge is socially situated, theory driven and produces tentative knowledge. They expressed views that the aims of research were to produce knowledge rather than 'truth'. This group also stated opinions that medical students tended to arrive at medical school with a view of science as certain, but those who entered the medical school with some experiences of university learning were more likely to appreciate the uncertain nature of science and therefore have a greater tolerance of the uncertainty within scientific knowledge as applied to medicine.

"You know, because there's still this perception in the basic science, it's concrete, you know…and I argue quite strongly that science is not concrete, you know, most of it's theory driven. Yes, there are bits that are more concrete than others, but actually a lot of the science is not solid."

Participant FAM01

"But I mean that whole idea of there being one scientific method for the sciences is nonsense, you know, I mean, I couldn't disagree with that more… actually formulating a good research question is quite a creative thing in itself."

Participant FAM02

"This is particularly Year One, yeah. So they see that the only thing that's really relevant to them is learning the factual science behind medicine. And so this notion that the factual science might be a bit uncertain, they struggle with, definitely."

Participant FAF03

Some participants in this group also said that they often taught sciences in medicine to Year One medical students as though they were certain and vaguely socially situated. Explanations for this included to not deviate from formal textbooks on medical student reading lists and in not challenging expectations of new students perceived to arrive at medical school with naïve personal epistemologies. In terms of *personal* epistemology, very close faculty interviewed would sit within Quadrant 4 of the figure charting the participant beliefs about the nature of scientific knowledge in medicine, indicating that scientific knowledge in medicine is both tentative, contextual and utilises constructed models of knowledge in its research applications.

6.6. Close Faculty

The 'close faculty' were medically qualified clinicians with a UEMS contract and who worked between 0.2 and 0.5 FTE for the medical school involved with the teaching of the BMBS programme. Of the six participants in this group, two were GPs and four were senior hospital doctors. For this group (and the distant faculty group) participants framed their responses to questions regarding the nature of science much more in terms of the ‘doing’ of science, as the application of clinical decision making, rather than in the ‘thinking’ about science. This group thought scientific knowledge and scientific research was socially situated, especially in terms of ethics and individualised patient responses to treatment. As a group, however, they typically used language about scientific methods that described evidence as having a factual basis and research aims in terms of seeking truths. In this group two participants specifically noted perceived differences in how research into natural sciences (including bio-sciences) and social sciences were viewed, with greater credence given to those medical disciplines in the biosciences and quantative research, as more objective and therefore accurate. Others expressed the uncertainty of scientific knowledge in terms of gaps in clinical knowledge, which they did not view a problematic for a practitioner, as this knowledge could either be sourced or would be discovered through future research.

> *“…because as you read a scientific article the potential angles that are involved are numerous, from the point of view of the researchers, the patients, perhaps those funding the study, the academic institution that’s doing it, even the journal in which it’s published…in some areas of biosciences, some of which are pretty dry areas, some of the pharmacology, they’re pretty – well yes, dry I think would be the best way I’d do that, they’re largely factual…. And one of the things I try and do in clinical practice is to try and cite examples of things where we’ve got it wrong in the past, and there are plenty of things that we have done in the past, spent money on in the past, where you look back and think ‘Well, how could we have been so daft as to do that’ or at the very least to say ‘Well, OK, we recognise that this was an error and let’s correct it.’ So you need to be able to look at the data in a critical way, so that you don’t make those errors again, or at least the chance of repeating them is kept to an absolute minimum.”*
>
> Participant FBM01

> *” I don’t know all the answers and none of us do… And so I suppose it is that repeated exposure to the fact that we live with the unknown, particularly in general practice, you*

know, massive sphere of which we know a very little about a very lot rather than a lot about a little".

Participant FBM02

"I think that trying to work out what is…good evidence, is quite hard and especially, I think, not so much for the very sciency topics, because I think sometimes that's more obvious… it's quite hard for them to realise that there is good sociology research and psychological models…"

Participant FBF03

In terms of personal epistemology, close faculty were more difficult to map on the figure charting beliefs about the nature of scientific knowledge in medicine. They held contrasting views regarding the nature of knowledge produced through social sciences and bio-sciences, although recognising that both played important roles in the creation of medical knowledge. In general they viewed the social sciences as socially situated and used constructed models of knowledge, that was more likely to result in the production of a tentative knowledge base (Quadrant 4 of the figure), but for bio-sciences, although having aspects of contextual models of knowledge (such as with research ethical considerations), there was a view that bio-sciences held a factual core and that tentative knowledge may be indicative of incomplete knowledge that was ultimately discoverable. Therefore, on balance these views most naturally sat within Quadrant 2 of the figure. This distinction of personal epistemological beliefs by domain specific epistemological beliefs reflects research findings by Schommer (1994a. 1994b) that epistemological beliefs are systems of more or less independent dimensions and that research participants can be more sophisticated in some beliefs but not others.

6.7. Distant Faculty

This group of three were medically qualified clinicians who received medical students on clinical placements, but were not more involved in the University education curriculum for a wide range of reasons. The group consisted of two hospital consultants and one GP. This group framed views about science in medicine and its knowledge base in a similar way to the ‘close faculty,’ in terms of applied medicine rather than theoretical scientific knowledge underpinning medicine. They viewed the practice of medicine as complex and uncertain, however, where comments were made about medicine’s scientific base, this was framed as solid knowledge and proofs.

> *“I think Year One they naturally stick with stuff that they can prove and they can almost – that is black and white… And you are given what is factual and what we know but then you’re told of the unknown and it stimulates you to do more research to go and read on your own, to look stuff up, to look at the latest evidence...But not every student is intrigued or stimulated by that, or stimulated in that way. They might think that’s a bit qualitative…* [at this medical school, medical students] *are encouraged to be reflective as opposed to just being scientific and factual”*
>
> Participant FCM01

> *“So I think there’s quite a lot of exposure* [in the media] *to the certainty of medicine, but actually the reality is not that, you know, in clinical practice. A lot of the time you’re coming up with what – not the best guess but what the most likely working diagnosis is, and running with that until something else comes up and it’s proven different.”*
>
> Participant FCF02

> *“I think probably they* [medical students] *think research is certain a lot of the time and therefore the diagnoses are certain. Whereas obviously as you go on you know that a lot of the time there’s a lot of uncertainty* [laughs] *in terms of treating patients… it’s like the best guess often, isn’t it?”*
>
> Participant FCF01

In terms of personal epistemology, distant faculty were comfortable with the notion of tentative scientific knowledge underpinning medical knowledge and, like the close faculty group, also believed that there was a factual basis to medical knowledge that could be established. They also framed their understanding of knowledge in terms of socially situated constructs (particularly regarding diagnosis – the doing of medicine and science). Therefore, from this small group of three participants it was difficult to get a handle on where this group sat within my figure of personal epistemologies. They also saw gaps in knowledge as the tentativeness of knowledge but that this could be a temporary state. Therefore, on balance this small group sit cautiously in the middle of all four quadrants on the figure.

6.8. Epistemological Mapping Of All Participants

This section shows the mapping of all participant groups on my figure developed to represent beliefs about the nature of scientific knowledge in medicine and conceptual models of personal epistemological development. The mapping for the distant faculty is ringed in a less solid line, to show that these findings are more cautious than for the other group findings.

The coding for the participant groups is as follows:

- A is Year One medical students' epistemological beliefs
- B is Year Three medical students' epistemological beliefs
- C is very close faculty epistemological beliefs (all sciences)
- D is close faculty epistemological beliefs about biosciences
- E is close faculty epistemological beliefs about social sciences
- F is cautious findings of epistemological beliefs of distant faculty

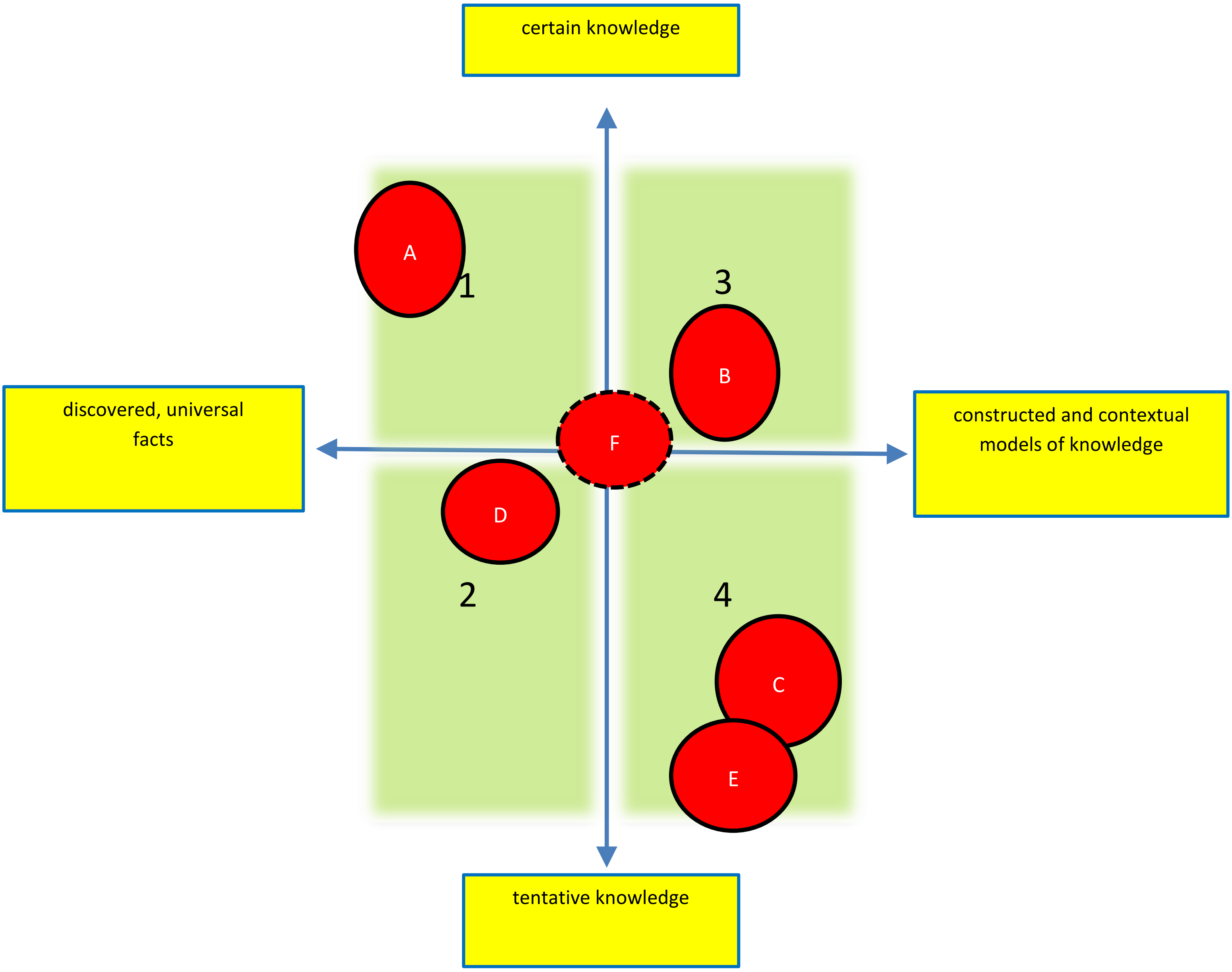


Figure M. Mapping Of Participant Epistemological Beliefs By Participant Groups

6.9. Summary Of The Chapter

In this chapter I have presented my findings regarding personal epistemologies about the nature of science and scientific evidence as applied to medicine for each of the five participant groups. I then presented these findings on a figure to represent where the groups sit in terms of epistemological development, informed by models of personal epistemology in education and psychology. These findings will then be discussed in Chapter 7, synthesised together with the findings from the previous Chapters 4 and 5.

Chapter 7: Transferability Of Findings To Other UK Medical Schools

7.1. Introduction To The Chapter

This chapter presents data from discussions about the potential for any tentative applicability of transferability of the findings from the thesis Chapters 5 and 6 to other UK medical schools. There were only two participants in this phase of the project design and I have chosen to not directly quote from the interview transcripts, as the participants may be identifiable from the quotes if presented in the thesis. As a case study, the findings in this thesis are contextual (Hetherington, 2013), in that they are unique to the local systems and history at UEMS/PCMD. However, case studies are defined by the subjects of their enquiry, which is the medical students and faculty (see section 3.2.1.). Like UEMS/PCMD, other UK medical schools employ faculty to teach medical students and are regulated by the GMC and its guidance documents, such as *Promoting Excellence: Standards For Medical Education and Training* (2015), and prior to this *Tomorrow's Doctors*. To look at any potential transferability of findings with respect to medical student development of personal epistemology, views of science and evidence (including attitudes towards uncertainty and complexity in medicine) and curriculum factors acting as barriers to, or enablement of in these areas, I interviewed two senior education leaders from two UK medical schools to explore whether my findings resonated with them at their medical schools. I will describe their reactions to my findings by the headings used in chapter 5; namely in terms of the 'nature of science', 'nature of medicine' and 'experiences of education.'

7.2. Comparing Curriculum Design Of The Medical Schools

I spoke with senior educationalists at two UK medical schools, both were medically qualified and had experience with curriculum deign and teaching in the medical schools. The medical schools that participated were Hull/York and Brighton & Sussex. These medical schools were set up around the same time as the Peninsula Medical School - PMS (latterly the Peninsula College of Medicine and Dentistry - PCMD and the University of Exeter Medical Schools -UEMS) and showed "considerable similarities in their approaches to curricular design and learning methods”, with key features such as an “integrated curriculum with patient contact throughout the course” (Howe et al, 2008, p.331). Although the Peninsula Medical School split into two separate institutions; Plymouth University Peninsula School of Medicine and Dentistry and the University of Exeter Medical School 2013, the curricula design at the two new medical schools remained relatively unchanged to that of PMS, at the time of the study, as a condition of set up by the GMC. The three medical schools (Hull/York, Brighton & Sussex and PMS) all introduced early patient contact for medical students from term one of year one, and all used GP and hospital placements. All used small group learning approaches, with Hull/York and UEMS/PCMD adopting problem based learning (PBL) and Brighton & Sussex adopting small group clinical symposia, as catch up sessions for medical students prior to workshops on a clinical day. There was cadaveric dissection at Brighton & Sussex, which was not used as a way of learning human anatomy at the two other medical schools. UEMS/PCMD was the only medical school of the three to use non-medically qualified faculty to facilitate small group learning sessions (via PBL) in year one of the course. All three medical schools had optional study units where medical humanities and social sciences were studied. All curricula incorporated elements of a spiral curricula design, where knowledge is built upon and revisited throughout the course, but with Hull/York and Brighton & Sussex teaching by ‘systems,’ such as heart/lungs/blood or muscular/skeletal and UEMS/PCMD teaching in stages of the human life cycle, for example starting with an infancy module in year one of term one.

Characteristics	UEMS/PCMD	Hull/York	Brighton & Sussex
Course	BMBS	BMBS	BMBS
Course duration	5 years	5 years	5 years
Date of first intake	(As PMS – 2002) 2013	2003	2003
Entry open to school leavers/ graduates	Yes	Yes	Yes
Small group learning	PBL	PBL	Weekly disease focused clinical symposia
Small group learning faculty facilitators (year one)	PhD graduates and medically qualified	Medically qualified	Medically qualified
Early patient contact at GP/hospital settings from term one, year one	Yes	Yes	Yes
Types of integrated curriculum	Stages of human development (year one), ‘pathways of care’ (years three and four)	‘Systems’ based	‘Systems’ based
Special study research based modules (choice) from year one	Yes	Yes	Yes

Table 9. Summary Of Curricula At UEMS/PCMD, Hull/York And Brighton & Sussex Medical Schools (adapted from Howe et al, 2004)

7.3. Comments By Other Medical Schools On ‘Nature Of Science’ Findings

I spoke with the two participants from other UK medical schools about my findings in relation to UEMS/PCMD medical students and faculty personal epistemologies about the nature of science and scientific evidence in medicine. Both representatives from the two other medical schools thought it was not surprising that medical students in Year One held more naïve epistemological views than Year Three medical students.

Their opinions were that students arriving from medical school directly from college may have had A level experiences that reinforced a ‘black and white’ and factual view of scientific knowledge. They reasoned this conclusion by relating to their own personal experiences of learning about sciences at school and college. Both participants thought that students entering medical school at a post-graduate level would hold more sophisticated personal epistemological beliefs about science in medicine, made more sophisticated by the experience of university learning. This view was expressed in terms of a general maturity of thought. However, this claim overlooks the course content as an undergraduate and how this impacts upon the development of personal epistemologies. Both participants also held the view that medically qualified clinicians (rather than faculty who were scientists and PhD graduates) would be ‘best placed’ to express scientific uncertainty of knowledge, through modelling this in a clinical context, as the *application* of scientific uncertainty. This expresses the view that the nature of science in medicine is best understood through its practical application. Both the other UK medical schools used medically qualified facilitators for Year One small group tutorials. Their reasons for this were cited as pragmatic factors in the setting up of their medical schools, rather than driven from any concerns over medical student epistemological development considerations.

7.4. Comments By Other Medical Schools On ‘Nature Of Medicine’ Findings

My ‘nature of medicine’ findings in relation to the research questions were with regard to medical students viewing medicine as a scientific discipline with a theoretical scientific knowledge base, but that the application of this knowledge base was viewed as a ‘craft’, and as such was perceived as artistry. Most students, in both Years One and Three, associated science with objectivity of method and art with subjectivity of thought and processes. Medical students viewed objectivity as a more credible methodological approach, and more ‘scientific’. Creative approaches were seen as less scientific. Therefore, there was a tension and disconnect between ‘solid’ (bio-medical) scientific knowledge and its application in the practice of medicine, which was associated with uncertainty in reaching diagnoses and complexity in decision making. The participants from the other UK medical schools thought that their Year One medical students arrived at medical school with views of both science and science in medicine as fairly certain and that a deeper appreciation of medical uncertainty (as diagnostic uncertainty) developed as the course progressed and was appreciated more fully from Year Four onwards. Both participants thought that the inherent uncertain nature of scientific knowledge was not addressed explicitly in their medical school curricula before year four, i.e. it was not formally structured as a taught element within the curricula, but in Year Four onwards this was part of optional medical student research projects. One of the participants, however, thought that their medical students would be particularly well prepared for encountering medical uncertainty because of early clinical placements from Year One onwards. They thought role modelling in apprentice style placements, where medical students were attached to a GP or NHS hospital ward, giving medical students 6 -7 half-day placements over the year, would mean that medical students learnt medical uncertainty by 'osmosis' from the clinicians they observed. They said that medically qualified clinicians and other associated health professionals would explain when clinical guidelines were not always followed (as clinical guidelines might be seen to imply certainty) and that by seeing examples of when clinical guidelines were deviated from would protect medical students from holding onto right/wrong perceptions regarding individualised patient diagnosis and care. This then modelled the uncertain and complex nature of medicine. The participants thought this would also help in the appreciation of scientific knowledge underpinning the practice of medicine as uncertain, not through a lecture system of discussing scientific knowledge and its approaches, but in seeing how medicine in practice worked.

7.5. Comments By Other Medical Schools On 'Experiences Of Education' Findings

I discussed with the two senior clinical academics the findings from my medical student and faculty participants regarding their experiences of education, both at UEMS/PCMD and elsewhere, in terms of learning about sciences and their application to medicine at medical school and development of personal epistemologies; whether this was enabled, influenced or impeded by the curriculum design. I had found that Year One medical students in their first term thought the development of independent learning skills (self-directed learning) at the medical school experienced through twice weekly problem based learning (PBL) small group sessions was difficult to master and was, at times, an overwhelming experience, unless they had experienced independent learning teaching styles pre-medical school entry. PBL is intended to help medical students engage with clinical problems involving complex and/or uncertain evidence. However, the Year One medical students adjusted quickly. By the second term of Year One, first year interviewees typically expressed comfort with the teaching structure within the curriculum and self-directed learning. The Year Three medical students, who were moving from a majority classroom-based learning environment into a mostly clinical learning environment also found this transition unsettling, citing increased levels of expectations for self-directed learning a major cause of stress and worry. There were two main strands to this anxiety. The first was about perceived less structure within the course as it developed. The second was regarding a feeling of overload in terms of figuring out how much depth of knowledge the medical students needed to go into in order to succeed on the course. Both clinical academics thought my findings would be similar experiences to those expressed by medical students at their medical schools. One of the medical schools did not use PBL, but had small group sessions (symposia) on ‘clinical days’ to discuss forthcoming disease presentations linked to systems of the body being studied to focus on during clinical placements. These small group symposia sessions included a self-directed learning element in preparation for the clinical placement session. However, on reflection, they also thought that PBL would probably be more effective in helping medical students in the early stages of the course appreciate medical uncertainty than the symposia. They believed PBL ‘would probably more overtly address’ medical uncertainty due to the range of topics included in PBL (such as bio-sciences, social sciences, ethical considerations), while their symposia were more concentrated upon biomedical concerns. However, they also thought that the symposia structure would be more instructive in defining the depth of knowledge medical students needed to explore on their placement and thus reduce medical student anxiety in this respect.

One of my findings was that Year One medical students held strong beliefs in the dominant relevance of bio-sciences to medicine. Many students questioned the value and relevance of taught medical humanities and social sciences within the

BMBS curriculum. Medical students in both years thought the relative valuing of non-bio-science topics at the medical school was reinforced through the type of questions appearing in examinations. By Year Three medical students had a developed understanding of the discipline of medicine as situated in a social context and had an appreciation of the course curriculum structured from Year One onwards to emphasise this. Both interviewees from the other UK medical schools agreed these findings resonated with medical student comments at their medical schools. They said that non bio-science elements of their courses were always the least popular with medical students and like UEMS/PCMD made up a small minority of exam or assessment questions, which they thought reinforced the low status of such topics in the curricula.

I had found that non-medically qualified faculty interviewed expressed views that the teaching of social sciences and medical humanities within the curriculum in conjunction with biosciences and exposure to clinical practice was a helpful tool to aid medical students with understanding medical and scientific uncertainty, such as with clinical decision making and research projects. The majority of medically qualified clinicians interviewed shared this view. However, in my research the robustness of social research compared with bio-science research was questioned by one senior clinician, signifying some wider views regarding the nature of scientific methods and evidence. The response to these findings by the other medical schools was that they agreed that the curricula should be broad in scope to stimulate debate regarding differing types of medical uncertainty and that there would probably be members of their faculty group casting doubt on research methods that they had no research experience with.

In my interviews medical students had expressed anxiety regarding the competitive nature of examinations at the medical school, including the progress test of applied medical knowledge (AMK). This led many, from an early stage in their first year of study, to seek out extra-curriculum sources of learning and tuition to develop strategies for maximising exam and assessment percentage marks. Some faculty expressed concern that applied clinical knowledge gained from the ‘hidden curriculum’ through tuition from student led medical society lectures was at odds with the teaching and learning aims of the BMBS curriculum; to establish the basic scientific principles underpinning medicine. Some faculty also highlighted that the competitive nature of assessments may also frustrate the cooperative ethos fostered during sharing of knowledge in small group learning, a central precept of the curriculum design at UEMS. Comments from the other UK medical school educationalists was that their medical students also sought additional tuition opportunities in order to seek a ‘competitive edge’ in the course, which meant they often ‘ran before they could walk,’ in terms of having insufficient underpinning knowledge to attempt assessment questions meaningfully.

My research found that the experiences of learning whilst on clinical placements appears was affected, either positively or negatively, by contact with individual clinical staff. This included their level of structured teaching aims and plans for the medical students they received, time available to teach medical students whilst simultaneously engaging in clinical practice and the length of clinical placement that medical students experience in fostering opportunities for deeper learning. Interviews with other medical schools echoed these findings and commented that medical student epistemological development was affected by the quality of learning on clinical placements, which could be negatively affected, particularly when unstructured.

7.6. Summary Of The Chapter

I interviewed two clinical academics from two other UK medical schools. These medical schools were set up and received their first cohorts of medical students around the same time as PMS. All three medical schools had similar a curriculum design. The comments were that my findings would likely have similar resonance at their institutions. There were differences, however, notably in the approach used at UEMS/PCMD in facilitating some small group sessions (e.g. PBL in Year One) with non-medically qualified academics. Whereas at the other UK medical schools medical doctors were used. For my research this was of interest, as the non-medically qualified faculty and the Year One medical students who attended PBL were the most divergent groups in terms of personal epistemologies in relation to the nature of science in medicine. A discussion of the findings in Chapters 4 – 7 will now be presented.

Chapter 8: Discussion

8.1. Introduction To The Chapter

This chapter synthesises the findings from Chapters 4 – 7 and integrates the findings with the existing literature (Chapter 2) across the different phases of the study design. The first part of the discussion is the key findings from the four phases of the project on the status of the nature of knowledge regarding science in the BMBS curriculum and personal epistemologies of medical students and faculty. I then discuss the key findings in terms of implications for theory, practice and policy. Following this is a discussion of the strengths of the project, including a presentation of the novelty of the research, and a discussion of the limitations of the project, including any factors affecting the confidence of conclusions reached. This chapter concludes with a summary, before moving onto Chapter 9, which draws conclusions and makes recommendations.

8.2. Key Findings

This thesis has explored medical students' beliefs about the nature of knowledge, particularly scientific knowledge and research evidence, at two time points representing key transitions in the undergraduate medical degree and considers influences from the formal, informal and hidden curriculum upon epistemological development. It has explored what the project participants and literature say about the relevance of scientific teaching in relation to medical practice and what the literature and participants thought about the nature of science and scientific methods.

The critical discourse analysis uncovered a current absence of guidance or reference to scientific methods in the most recent publication on medical education by the regulator of medical schools in the UK, the GMC (*Standards for Medical Education and Training*. 2015). The approach to the attainment of scientific knowledge to underpin medical practice was unspoken. This reflected a trend over the last two decades in the document of reducing definitions to scientific approaches to a single scientific method (within the bio-sciences), to finally saying nothing about scientific approaches in 2015. This either suggests that the GMC is concerned only with the application of scientific knowledge in clinical practice, or that they believe medical schools are best placed to set their own approaches to the teaching of scientific knowledge, methods and research approaches. I believe that the 2015 GMC document indicates, through the absence of discourse on scientific approaches in medicine, that this had been ‘normalised’ and the accepted norm is that when talking about science in medicine this is assumed to mean the application of a positivistic and experimental methodology, associated with the ‘discovery’ of ‘facts’ and ‘truth’ claims. I also suspect, from following *Tomorrow’s Doctors,* (2009) that GMC guidance allies itself with a scientific deductive model, such as used in randomised controlled trials (RCT), where the assumptions are, if the tests are met, that a positive result implies an appropriate causal conclusion and that this is accepted as the ‘gold standard’ for research. I think that medicine is the model for how research and practice should relate to this gold standard. However, Cartwright argues “that with all deductive methods, the benefit that the conclusions follow deductively in the ideal case comes with a great cost: narrowness of scope….[and that]…There is no gold standard” (Cartwright, 2007, p. 11). Nonetheless, with current GMC curricula guidance saying nothing about scientific methods in medicine, this may be an indication of when a discourse had become so powerful, as an accepted ‘truth’, that it is unquestioned (see Ferra, 1995), and in this instance the perception being that there is only *one* way of approaching science. This would be at odds with the counter discourse expressed in the concluding consultations by GMC and the King’s Fund (a UK health charity that shapes health and social care policy and practice), who consulted widely, including contributions by medical educators and patients, and which recommended that medical students be introduced to a “range of problems, presenting to doctors a range of possible solutions” for attaining knowledge (Lowry, 1992).

By carrying out the discourse analysis critically I explored where any counter or dissonant discourses regarding approaches to knowledge acquisition were addressed within curricula guidance documents. I found different and dissonant discourses regarding methodological approaches towards the bio-sciences and the social sciences. Bio-sciences were generally associated with quantative method(s) and the social sciences with qualitative methods. These associations had implied epistemological assumptions and I found that the assumptions lay on directly opposite quadrants of the chart I developed to indicate such epistemological assumptions. For example, in *Tomorrow's Doctors* (2009), epistemological assumptions regarding bio-scientific knowledge sat in the quadrant that assumed such knowledge concerns discovered, universal facts and that this knowledge could be certain. The epistemological assumptions regarding the social sciences sat in the quadrant indicating that this knowledge was contextual, socially constructed and produced tentative knowledge (see Figure H). Such assumptions serve to polarise views about research and evidence within bio-science and social sciences and leads to value judgements about the status of the research produced (such as what is 'gold standard' or not) and the curriculum content (Whelan, 2009). In interviews with faculty who had no experience with conducting qualitative research I heard examples of expressions of doubt cast regarding the trustworthiness and value of such research because it was viewed as subjective and socially constructed evidence. This leads to further questions regarding faculty development and attitudes toward differing types of research methods.

A key finding regarding perceived differences between bio-scientific methods/scientific methods within the natural sciences and social sciences or the humanities was that almost all Year One medical students and most Year Three medical students identified 'objectivity' with the bio-sciences/natural sciences research and 'subjectivity' with social sciences and humanities research. These polarising views led to a perception that something 'arty' was associated with subjectivity, was creative, and was influenced by feelings and emotions. These descriptive adjectives were seen as counter-productive or superfluous to the goals of science, to produce 'factual' or certainty within knowledge. This led to perceptions about what counted as authentic scientific evidence. Kuper et al define this as evidence that is "privileged, included or excluded" (Kuper et al, 2007, p.163). Year One medical students especially viewed 'sound' 'objective' scientific approaches in terms of logic and proof attainment (see section 5.4.1) and the development of known 'rules' of thought (see section 5.4.2.1). Through these polarised perceptions regarding 'arts' and 'sciences', many Year One medical students appeared to buy into several distortions regarding the nature of science, including that science lacks creativity, is free from the influence of emotions and the knowledge produced is not of a tentative status. The Year Three medical students had greater appreciation that scientific knowledge may contain uncertainties and tentative knowledge (section

5.4.1) but still tended to perceive ‘arty’ attributes with creativity and unsure knowledge, as knowledge gaps which could be overcome. The less a topic within the curriculum was perceived as ‘arty’ (anatomy, surgery), the more medical students perceived this as being associated with research objectivity. However, counter-discourses were apparent and reflected a more nuanced account of skills and approaches within medicine. Where medical students had studied non-natural sciences such as psychology, at A level or degree level, in addition to the natural sciences, such as biology, chemistry and physics, prior to entering the medical school, these students were more likely to perceive all research approaches and all application of sciences as creative and subjective processes. The responses of these medical students indicated a higher tolerance of uncertainty within the scientific basis of knowledge underpinning medicine. However, generally amongst the medical students there was a perceived negative association between ambiguity or uncertainty of scientific knowledge/research and confidence in decision making in clinical practice. Medical students were likely to perceive this as incomplete knowledge, rather than uncertainty as being something inherent within the nature of scientific knowledge itself or a feature of clinical decision making that has to take into account wider concerns, for example, cultural acceptability of a treatment, economic viability of a treatment etc. Luther and Crandall (2011) argue that these negative perceptions regarding medical uncertainty and ambiguity can “potentially influence career choices” (p. 800), and that medical educators should be more deliberate in educational practice when teaching medical students about ambiguity and uncertainty in clinical practice. I agree with this but in addition urge that educators not only address the ambiguity and uncertainty in clinical practice by talking about and acknowledging it, but go one step further and address these issues within the attainment of scientific knowledge that informs clinical practice by talking about and embracing its existence and admiring the role that ambiguity and uncertainty within scientific theory and knowledge adds to scientific research and practice.

In Chapter 6, theory-led participant findings, I mapped where the participant groups lay on a chart that I had developed, informed by conceptual models of personal epistemological developments. The mapping related to personal epistemologies regarding the nature of science, or the values and assumptions “inherent to science, scientific knowledge and/or the development of scientific knowledge” (Lederman et al, 1998). This mapping considered what participants had said regarding the certainty or tentativeness of scientific knowledge in medicine, and how socially isolated or socially situated such knowledge was. This included participant statements from task groups and semi-structured interview, such as subjectivity/ objectivity, creativity, social and cultural embeddedness, empirical base, testability, independence of thought. The task group exercise with Year One medical students had been set up to explore such perceptions and the subsequent semi-structured interview questions with the medical students in Years One and Three and the faculty had been informed by the task group responses and concurrent observation of learning episodes. The findings indicated differences in where the groups lay in terms of models of epistemological development.

Quadrant 1 of the chart reflected the expressed views of most Year One medical students. Quadrant 1 indicated views that scientific knowledge is more or less independent of cultural location and sociological structures, that science is procedural, rather than creative in process, and that the type of knowledge produced by science, compared to knowledge in other disciplines (such as the arts, humanities and social sciences) is more objective and unbiased. Quadrant 1 also indicated belief in scientific knowledge that is more fixed and certain; that science and its methods provide absolute proofs and that evidence accumulated carefully will result in such knowledge. Quadrant 1 suggests that those whose personal epistemologies match Quadrant 1 express belief that scientific hypotheses develop into theories, which in turn become laws and that scientific laws are absolute, and that general and universal scientific methods exist. These views are closely associated with naïve epistemological beliefs about the nature of science. The Year One medical students explained their viewpoints primarily in terms of learning science at pre-university level courses, and suggested that sciences, such as the natural sciences and maths, were taught in terms of fixed and absolute concepts. Most Year One students expressed views that social sciences and the humanities were ‘beyond’ medicine, and therefore their expressed views about science in medicine referred to subjects not perceived as either the social sciences or the humanities.

Quadrant 2 is similar to Quadrant 1, with the exception that scientific knowledge in medicine was viewed with greater tentativeness and uncertainty compared to Quadrants 1 and 3. However, this tentativeness and uncertainty was often perceived by participants mapped to this quadrant as a temporary state, due to incompleteness of knowledge or knowledge gaps, which could be overcome through more research or learning. Like Quadrant 1, those whose personal epistemologies most closely matched Quadrant 2 indicated that general and universal scientific methods exist. In this quadrant I placed close faculty's expressed perceptions regarding the bio-sciences (but not the social sciences). This view of scientific knowledge produced in the bio-sciences, but with a caveat regarding tentativeness of knowledge expressed as incomplete knowledge, was similar to the views expressed by Year One medical students. I think it is reasonable to postulate that a reason that the Year One medical students expressed greater belief in the certainty of knowledge was due to lack of experience of exposure of gaps in knowledge, which the close faculty would have direct experience of within their chosen field of medicine.

Participant groups placed in Quadrant 3 expressed beliefs about the nature of science in medicine suggesting that scientific knowledge and scientific processes were interdependent within the cultures where scientists reside and where the scientific research takes place. This indicated that scientific knowledge is historically, technologically, socially, and culturally conditioned. However, Quadrant 3 also reflects viewpoints that knowledge can be fixed and certain, that science and its methods provide absolute proofs and that evidence accumulated carefully will result in such knowledge. Therefore groups situated in Quadrant 3 appeared to hold contradictory viewpoints regarding the socially constructed nature of knowledge and truth claims alongside strong beliefs regarding the 'certainty' of truth claims within a social paradigm, for example regarding the status of Western medicine. I placed most of Year Three medical students within this quadrant. Their responses to interview questions were interesting. I found that explanations regarding certainty of knowledge and the constructed and contextual nature of scientific knowledge seemed to co-exist. This group of medical students appeared to be transitioning and challenging viewpoints from what they may have held when they had first entered the medical school. Therefore, contradictory viewpoints would be a natural state as they made sense of what medicine and medicine as a science was. There remained some naïve epistemological beliefs about the nature of science associated with certainty of knowledge, however, this was moving more toward the tentative knowledge quadrants. Year Three medical students also expressed appreciation of the constructed social nature of evidence both in bio-science and non bio-scientific research in medicine and a realisation that medicine as situated in a social context, which most Year One medical students did not have a grasp upon. However, Year Three medical student viewpoints were closely aligned with a Western model of medicine and a rejection of other models as ‘unscientific’ and therefore false. This is an example of the contradictory nature of a transition state.

In Quadrant 4 sat the very close faculty group and the close faculty group’s view regarding the social sciences in medicine. This quadrant (like Quadrant 3) suggested that views expressed reflected acknowledged the historically, technologically, socially, and culturally nature of research and evidence that was also open to debate and challenge. Quadrant 4 indicated an awareness of relativism debates within enquiry and a view of complexity regarding the nature of knowledge in medicine, produced by theoretical approaches. The group within Quadrant 4 did not view scientific knowledge in terms of its verisimilitude, but rather in terms of the novelty and application that scientific research produced. Like Quadrant 2, Quadrant 4 indicated that knowledge produced by science/social science (very close faculty), social science (close faculty) was likely to be tentative and uncertain, and that these were inherent characteristics of these types of knowledge. What was of interest was that it was the very close faculty (those typically without a medical degree), who typically held a PhD either within the bio-sciences or social sciences who had views most aligned with models of epistemological development indicating the most sophisticated levels of personal epistemological development regarding the nature of science. This group were also typically involved in research at the University, suggesting that there may be an association with publishing research, peer review, justifying methodological choices and development of sophistication of personal epistemological beliefs. In contrast, where the close faculty described the characteristics of the social sciences, which put their responses within Quadrant 4, their expressed opinion regarding the tentative nature of the knowledge produced in social science and its socially constructed basis was more likely to be viewed negatively, for example as ‘just a theory’ (see Elby & Hammer, 2010), in contrast to the nature of knowledge produced by bio-science research, which was viewed as more reliable and therefore more worthy of reputable status. Recent research into medical students’ epistemological beliefs (Assenheimer et al, 2016) also found that there are differences in “beliefs about knowledge in different sub-disciplines of medicine” (p. 110).

I placed the distant faculty cautiously on the intersection of the axes of the four quadrants (distant faculty were medically qualified and received medical students on clinical placements, but unlike the close faculty, did not hold a contract with the medical school). This was due to there being only three participants in this group, and that this group had the most difficulty in expressing personal epistemological viewpoints, they indicated they were mostly removed from research processes. The three participants within this group also expressed diversity in personal epistemological viewpoints, making their views difficult to reach conclusions upon. However, this could indicate that within distant faculty exists a wide range of personal epistemological viewpoints, which appears more uniform in other faculty groups. This would have learning implications for medical students when placed with the distant faculty and for the partnership model between the University and hospitals/community placements and the nature of unplanned learning experiences within a planned curriculum.

There were variants within the generalised representation of medical student groups mapped. The variations tended to be that older students arriving at medical school (with or without a first degree) appeared to hold more sophisticated epistemological beliefs than medical students aged 18 in Year One. The clinical academics from the two other UK medical schools to whom I presented my initial findings held views that medical students entering with first degrees would hold more sophisticated epistemological beliefs as a result of both maturity and education. I, however, found that not having first degree, but being older, was also an indication of more sophistication within personal epistemological beliefs. These findings are at odds with Schommer (1990, 1994b) who linked higher education levels with more sophisticated epistemological beliefs, where my research suggested that this may not be necessarily so. The views of older university entrants (>20 years old) were more aligned with year three medical students, who generally sat in Quadrant 3 of the chart. An important question is whether age leads to maturity of thought even without curricula? This is a question for future research using concepts of psychosocial maturity, something that I have not explored in the thesis research questions. It is of interest, however, that those medical students in both Years One and Years Three, who had studied both the natural sciences *and* arts, humanities and/or social sciences prior to entering medical school, whilst representing a minority of medical student participants, seemed to have the most sophisticated personal epistemologies of the whole medical student group regarding science and scientific knowledge in medicine. Their personal epistemologies expressed put these individuals into Quadrant 4 (with the very close faculty). This suggests something about pre-university curricula within these subjects that made students studying such courses comfortable with notions of tentativeness and uncertainty of knowledge constructs that they easily transfer to medicine and the scientific knowledge that underpins it. I suggest that there may be something about being used to tackling open-ended structured questions in assignments (called ill-structured problems in the personal epistemology development literature, where there may be a number of solutions or approaches to a problem) that leads to the development of independent thinking skills pre-university and accelerated epistemological development. New medical students not used to this type of learning approach experience this in Year One at UEMS via problem based learning (PBL) sessions and it takes time to develop a sense of comfort with this learning approach (see section 5.6.1 and section 5.6.2). My findings fit with Hofer's contention that disciplinary differences (or in this case courses undertaken) are significant in terms of shaping personal epistemological constructs (Hofer, 2000). It was curious that the close faculty viewed social sciences as occupying Quadrant 4 in terms of epistemological constructs, but that this was viewed as less valued in terms of desirable knowledge constructs compared with science and evidence as knowledge produced in the bio-sciences. This view of differing contexts and constructs within the different disciplinary domains of medicine is an indication of what Elby and Hammer (ibid) call "epistemological coherence [that] is often local rather than global" (p. 3). They argue that people often manifest different coherent epistemologies in different contexts. My findings, however, indicated that people may manifest different epistemologies in different contexts, but that these may also be incoherent.

What is also of interest is that the epistemological mapping of the key policy guidance documents by the UK regulator of medical schools, the GMC (see Figure H), had no entry for the most recent guidance document (*Standards for Medical Education and Training*. 2015) due to the document being silent regarding scientific approaches to methods and research in medicine, thus the most current guidance document that I could map was *Tomorrow's Doctors* (2009). Like the close faculty, the discourse about knowledge in medicine was different depending on whether this related to bio-medical knowledge (discovered, universal facts) or the social sciences, including psychology (constructed and contextual models of knowledge). I placed the discourses regarding these knowledge constructs on opposing quadrants in my model of epistemological constructs, with the discourse regarding bio-medical knowledge in Quadrant 1 and that regarding social sciences and psychology in Quadrant 4. This indicated that these constructs were as far apart as they could be in terms of epistemologies. What this might mean in terms of implications for practice will be discussed later in this chapter.

It has been argued by a number of authors that teachers' personal conceptions of the nature of science do not necessarily influence classroom practice because what teachers say or do in classrooms does not always reflect their personal epistemological standpoints (Lederman, 1992. Monk & Osborne, 1997. Dolphin & Tillotson, 2015). My research found that Year One medical students and very close faculty (who taught Year One medical students in PBL sessions) were the most distant groups of participants within the study in terms of personal epistemological development, and therefore mismatched. The very close faculty expressed views regarding the nature of scientific knowledge that were tentative, socially constructed and contingent. However, this group also professed to teaching scientific knowledge in medicine to Year One students as though it were certain and only vaguely socially situated and constructed. Clearly there is something odd going on; that those with the most sophisticated personal epistemologies were framing their teaching through a naïve lens. Some of the group explained this in terms of not wanting to deviate from the formal curriculum, citing text books for suggested reading to medical students that were written from the position of positivistic certainty. This group said that Year One medical students tended to hold naïve epistemologies regarding the nature of science in medicine, but not that the medical students in Year One were unable to be challenged in their views. One explanation may also be the possibility of very close faculty meeting the perceived expectations from Year One medical students of what science knowledge in medicine is, in satisfying these needs and not challenging them, in the same way that the course meets the perceived expectations of what topics are relevant to medicine.

There were strong perceptions expressed regarding the dominance of the bio-sciences within the curriculum. These perceptions were reinforced by the UEMS reading list for new medical students. In 2014 (the intake year of my Year One medical student participants) the list had over 50% of books dedicated to bio-sciences, the rest of the list spread between clinical skills, population health, psychology, research skills, professionalism and medical ethics (see Table 7). The list reinforces the dominance and value of bio-sciences within the curriculum.

Medical students expressed views that bio-sciences was recognised as medicine, core information and synonymous with clinical knowledge and that tutors with a background in of bio-scientific knowledge were perceived as having expertise that was valued. Medical students and faculty also referred to the dominance of bio-science questions within assessments, serving to reinforce such views. Conversely the social sciences were perceived as associated with knowledge, rather than application of medicine and therefore outskirt information or 'beyond medicine'. Social sciences were expressed in terms of 'common sense' and able to be learnt by assimilation (role modelling in practice), thus contradicting the 'knowing' rather than 'doing' of medicine, and inhabiting a domain of less scientific rigour, but also complicated, hard and difficult to research, all of which contradict claims about the subject as 'common sense' and learnt be assimilation (see Figure K). A paper by Kitto also indicated that social sciences, and in particular sociology, was perceived by medical students as being particularly complicated and that medical students struggled to understand how this related to medicine. Kitto reported that medical students viewed the subject as abstract and therefore removed from the "concreteness of hard sciences," meaning that medical students did not see the relevance to "science-based medical practice and clinical effectiveness" (Kitto, 2004, p.82). However, Haidet and Stein argue that social sciences within the curriculum are often viewed negatively by medical students as not primary goals of medicine. However, their significance within the curriculum is of benefit to fostering understanding of the uncertainty and complexity within medicine (Haidet & Stein, 2005).

An important aspect of the findings was how the ‘informal’ and ‘hidden’ curriculum differed from the ‘formal’ curriculum and how this could be a barrier to personal epistemological development. The official curriculum could be explored by observing medical student timetabled learning episodes, such as PBL groups, where the problems were designed to elicit an array of likely clinical diagnoses. I attended five PBL sessions and observed facilitators allowing the Year One medical students to explore a range of diagnoses. However, when the medical students presented bio-scientific evidence to support their conclusions, this evidence was rarely challenged as tentative knowledge, but ‘corrected’ if an error was thought to have been made. In lectures for Years One and Three medical students I observed that the vast majority of presentations suggested that the scientific knowledge informing the topic within medicine was presented as a solid knowledge base. Research papers were mentioned to support these claims, with the exception of a psychology lecture where research papers were cited that held differing viewpoints on the topic presented. These observations suggested that the ‘official’ curriculum mirrored epistemological assumptions regarding the nature of science from high level key policy and guidance documents issued by the GMC. This leads to a questioning of how uncertainty within the scientific knowledge base of medicine is modelled by faculty, by those who do not share the ‘official’ epistemology, such as the very close faculty, in the early years of the BMBS curriculum. An aspect of the ‘informal’ curriculum was opportunistic learning whilst on clinical placements, including the time constraints upon clinicians receiving medical students to plan for learning episodes or review the learning that the medical student thinks has taken place. One concern might be that clinicians, due to time constraints, model certainty when faced with clinical urgency. However, both Year One and Year Three medical students gave ready examples of clinicians modelling diagnostic uncertainty, whilst on wards or in the community, within highly pressured situations. The medical students spoke about the tentativeness of diagnosis as apparently woven into the fabric of role modelling clinical practice during their encounters. What medical students did report was, however, limited modelling of scientific uncertainty as a contested knowledge base in medicine as articulated by clinicians. Medical students spoke about knowledge bases being incomplete as a form of uncertainty and this was viewed as something that was likely to be overcome in time through more research. There was a ‘hidden’ curriculum at the medical school, where medical students were members of medical and surgical societies, sought extra tuition in the form of society lectures, in order to gain a perceived advantage in assessments. The concerns expressed by faculty was that this may be counter-productive in terms of learning and personal epistemological development because it was perceived that society attendance and discussions held at meetings about assessment questions encouraged medical students to attempt assessment questions without formal instruction within the official curriculum. However, it may be blinkered to view medical and surgical societies in such negative tomes; having medically trained parents or scientist parents, joining medical social media discussion groups or having a health related first degree before entering medical school could all equally influence assessment performance and/or epistemological development.

8.3. Implications For Theory

This thesis has been a case study, its context informed by activity theory. The methodology has also taken an interpretative methodological approach across the four phase design, with aspects of critical theory (in Phase One, the critical discourse analysis) and use of a new model of personal epistemological development (Phase Two), informed by theory in education and psychology. By defining the context of the case study by activity theory, this set the scene for the constituent parts of the research to ensure that the case study was comprehensively explored. Critical discourse analyses with a Foucauldian lens is a theoretical methodological perspective that has been used to explore discourses within medical education more frequently in the last decade, through studies such as those by Cynthia Whitehead and Brian Hodges, medically qualified doctors and PhD graduates with an interest in medical education, who are based in Toronto, Canada. The variety of methods used in the different phases of the research has been considered to craft a research design to effectively address the research aims, embodied as a theoretical understanding of how medical students, at key transition points, view science and scientific evidence in medicine by exploring how this understanding relates to their views about the nature of science.

The implications for theory have been the questions and debates that the phases of the project have found. The critical discourse analysis in exploring notions of power and influence within curricula documents through an analysis of the discourses about defining science and scientific methods and scientific content within undergraduate curricula has exposed biases within curricular content toward a normalisation of positivistic experimental notions of scientific method within medicine, the dominance of bio-sciences within the curriculum and that this is reinforced through medical school assessments, teaching epistemologies and the negative perception of the role and relevance of non bio-scientific subjects included within the curriculum. The absence of statements in official guidance curricula documents from the GMC regarding the construction of scientific knowledge in applied medicine implies that the theory of 'how we know' is not as important in medicine as 'what we know.' I have argued that the 'how we know' is important for developing epistemologies and values in scientific medical research and in developing an understanding of uncertainty within medicine. By not exploring this explicitly within the curriculum there is danger that uncertainty is viewed as something to be 'managed' and that the uncertainty conditions in which medical education research sits is something to be overcome (Park et al, 2014), rather than embraced.

I developed a simple mapping tool of personal epistemological beliefs about the nature of scientific knowledge in medicine from existing models of personal epistemological development. My thesis has added to research in education and more recently medical education regarding personal epistemologies about the nature of science. There have been no published studies that have looked at two cohorts of medical students in the same medical school from two different year groups, faculty involved in the teaching of such medical students and the explicit or implied epistemic values of key policy documents from regulatory bodies overseeing undergraduate medical education during the 20th and 21st Centuries. My findings identified extensive variations in epistemic views about the nature of scientific knowledge in medicine over the years, in line with recent publications on the nature of science in medicine (Rambihar, 2000. Rochel de Camargo JR, 2002. Cohen & Hersh, 2004. Whitehead, 2011. Ng et al, 2015). My findings also indicated mismatched personal epistemologies between first year medical students and faculty, greater sophistication of personal epistemologies within the year three medical student group and a wider spread of personal epistemological beliefs the more distant faulty relationships with the medical school were. This leads to questions to which faculty are best placed to influence the development of epistemological beliefs regarding the nature and role of scientific knowledge in medicine and to support medical students in being able to appreciate and deal with the inherent uncertain nature of medical practice and decision making. It has been asserted by Ghosh that “most medical schools do not…teach students how to deal with medical uncertainty” (Ghosh, 2004, p.741). This is compounded if faculty, even if contrary to their own personal epistemological beliefs, are teaching about scientific knowledge in medicine as something that is solid, or more solid in some disciplines than others and divorced from social constructs, based on the teaching context and unclear curriculum goals. This implies that policy and curriculum aims need to be more aligned and explicit to support faculty members delivering the curriculum (see Dolphin & Tillotson, 2015).

8.4. Implications For Practice

In this thesis I am presenting the argument that to prepare junior doctors for practice that these junior doctors need to be able to appreciate and be adequately prepared for decision making in what is a complex and ambiguous clinical environment. This means having learnt whilst at medical school to understand research methods, evaluate evidence and have an understanding of how knowledge is constructed and acquired. This suggests that looking at the nature of science and evidence in medicine matters to knowledge development in order to prepare medical students for the complexities they will encounter within practice. The problems for preparing medical students to be tolerant of uncertainty within the scientific knowledge informing medicine is the variety of personal epistemic views that the Year One medical students expressed in the first term of their course. For many, for example when talking about anatomy, there appeared to be a denial that any uncertainty was present, as all answers were ‘right’ or ‘wrong’. For a minority of others, who cited role modelling by teachers at the pre-university level regarding uncertainty in scientific knowledge, there appeared to be an acceptance, comfortableness with and tolerance of notions of uncertainty throughout science and medicine. I contend that a goal within undergraduate medical education is to increase tolerance of uncertainty in relation to medicine because of the personal and professional benefits current research suggests this brings. For example, one study, (in Wayne et al, 2011) found that medical students with higher tolerance of ambiguity tended to demonstrate less compassion fatigue toward patients over time compared with medical students who had shown lower tolerances of ambiguity. Nevalainen et al associate uncertainty in clinical practice with increased stress, anxiety, feelings of dread, ignorance and denial. They cite 20% of “fifth year medical students experience difficulty tolerating uncertainty when making medical decisions” (Nevalainen et al, 2012, p.243). The authors argue that an increased tolerance of uncertainty reduced negative emotions, implying this improves performance and the ability to engage in decision making and also impacts upon career opportunities, opening up careers in specialities perceived as more affected by ambiguity and uncertainty. However, Hancock & Mattick (2012) urge caution regarding potential “unintended consequences associated with moves toward increasing undergraduates’ tolerance of uncertainty” (p.834). Increased tolerance of uncertainty could potentially impact upon speciality job choice selection, toward specialities perceived as more ambiguous, leading to possible supply of personnel issues. But, to increase tolerance of uncertainty, curricula need to incorporate opportunities for medical students to discuss scientific and medical content without arriving at a certain answer. At UEMS, problem based learning is designed to foster this through motivating independent learning skills in clinical based scenarios that contain complex and uncertain knowledge. However, the role that the value of social science methodologies may have in fostering the development of epistemic valuing of tolerance of uncertainty for clinical decision making and scientific research is an area worthy of future research. The Year One medical students who took part in my research at two points in the academic year (at the mid-point of term one and the beginning of term two) reported adapting to the course structure within PBL relatively quickly and the demands of independent learning without undue problems. This indicated the adaptability of Year One medical students in their pedagogical and epistemological outlooks. It is reasonable to infer that similar shifts in personal epistemological viewpoint regarding the nature of scientific evidence and research in medicine could be achieved through curriculum design and delivery. When discussing my initial findings with two other medical schools, their feedback concurred that PBL design was one good way to overtly address medical uncertainty in the formal curriculum. Medical education literature subscribes to the view that PBL in the form of open-ended problems that require thinking and re-thinking as uncertainties emerge, become resolved or re-emerge, bring personal epistemologies to the fore (Assenheimer et al, 2016) and have a positive effect on the development of personal epistemologies (Bientzle, 2014).

Bringing personal epistemological beliefs to the fore in the form of integrating the nature of science formally into teaching sessions could aid medical students in expressing their own beliefs and for faculty to identify what these range of beliefs were. However, Assenheimer et al (ibid) caution that “large numbers of lectures and poorly designed PBL cases risk reinforcing beliefs rather than challenging them” (p. 110).

In my research I found mismatches between personal epistemologies of the broad group of year one medical students and very close faculty, who acted as PBL facilitators to year one medical students. This mismatch could be viewed either as a positive feature, in supporting the medical students to develop on their journey, or as a negative feature, in that it could lead to frustration. Whether this works positively or negatively could depend upon the epistemological development aims (such as fostering debates about medical and scientific complexity and uncertainty, or promotion of a ‘sound’ and ‘solid’ scientific base within medicine, such as through hypothetical-deductive model at odds with faculty personal beliefs) within PBL (see Water-Adams, 2006).

Therefore, faculty development and positive role modelling is important in challenging and developing medical student epistemological beliefs. This might be achieved by explicit course aims with regard to modelling personal epistemological belief to foster development. In my observation of learning episodes I saw examples of implicit faculty personal epistemological beliefs but a dearth of explicit signposting of epistemological concerns. By including a pedagogical emphasis in teaching sessions on learning goals focusing on medical students constructing and acquiring scientific knowledge in medicine, “rather than on student attainment of discrete scientific and epistemic ideas” (Berland et al, 2015, p.1083), this would integrate and align the development of personal epistemologies into the whole system of the curriculum to support deep learning (Biggs, 2002). This may mean adjustment of partnership models with hospitals and community health placements to provide clearer scaffolding to medical students in consciously and formally personally constructing their knowledge about science in medicine in partnership with clinicians, rather than the current model where informally ‘opportunistic’ learning or the ‘hidden’ curriculum exist, where learning is by ‘osmosis.’ Building relationships with the faculty receiving medical students on clinical placements is essential for the learning experience so that appropriate scaffolding can be provided and appropriate methods for the withdrawal of scaffolding, an important social constructionist principle, can be developed. My research with medical students and faculty indicated that they perceived the course to be less structured as the course developed (Figure J). However, there is a question to whether the structure or scaffolding is sufficient to start with. Introducing more structure in years three of the course onwards, where most learning takes place in clinical placements, may provide less of an abrupt transition (reported by the Year Three participants) from the mainly University based years one and two and the, mainly, clinical placements from year three onwards. This would still support the development of independent learning, with it being promoted through meaningful tutor/clinician scaffolding to improve learning whilst on clinical placements.

8.5. Implications For Policy

Inclusion of the sciences as a knowledge base is a key feature of curriculum design in medicine and substantial time and resources are directed towards this. Chapter 2 explored definitions of science in medicine and some of the taken for granted assumptions of what makes knowledge scientific. When definitions or approaches become ‘norms’ this makes discourses accepted and dominant interpretations seen to express something that is true and not underpinned by ideology or personal and cultural epistemology. ‘Norms’ of discourse become powerful and persistently promoted. For example, that the scientific zone of *knowledge* in medicine is “fact based, predictable, and consists of solvable problems” in contrast to the uncertainty of the *practice* of medicine that is “characterised by uniqueness, conflict and ambiguity” (Luther & Crandall, 2011. p.800). This is the potential of critical discourse analysis, to expose influences of dominant discourses in shaping intellectual authority within institutions, which is then either challenged or reproduced. The current UK GMC guidance for undergraduate medical education takes the form of an outcomes based competency framework, which is concerned with performance, defined by a set of professional roles. Whitehead et al (2014) argue that such frameworks are less concerned with knowledge acquisition. By stressing the intended learning outcomes, there is danger that the ‘inputs’ and processes (of knowledge acquisition; the *scholar* in the *Tomorrow’s Doctors* ‘doctor as a scholar and a scientist') and integration between theory and research skills and 'outcomes' becomes unbalanced because the curriculum becomes 'swamped' with outcomes. This leaves Orpwood and Barnett to wonder of outcomes competence frameworks if "there is any science left" in these types of curriculum documents (Orpwood & Barnett, 1997, p340). It has also been argued that outcome-based frameworks can serve to either avoid or 'settle' disagreements of an epistemological nature as the guidance has been written by 'experts' within the profession (Park et al, 2014). By not including statements about methods to acquire scientific knowledge in the most recent UK outcome based framework for medical education, this suggests that the debate has been settled and remains as propagated in the 2009 version of *Tomorrow's Doctors*, that scientific knowledge and scientific research in medicine is obtained through an experimental positivistic method, to include *"the evaluation of scientifically established facts and the analysis of data"* (Tomorrow's Doctors, 2009, p.83, see thesis Chapter 2, section 2.2).

Current undergraduate curricula, including assessment, remain dominated by bio-scientific topics. Biggs quotes Ramsden (1992) as asserting that students "learn what they think they will be assessed on, not what is in the curriculum" and as such that "the assessment *is* the curriculum" (in Biggs, 2003). Non bio-scientific topics were viewed by most medical students in my study as less relevant to the discipline of medicine, particularly by Year One medical students, with this viewpoint shifting somewhat within the Year Three medical student participants. Yet, I found that medical students who had studied social sciences to at least A level standard (or equivalent) prior to entering medical school, expressed more sophisticated personal epistemological beliefs regarding the nature of science, and seemed to have a higher tolerance of uncertainty and ambiguity of scientific theoretical bases. This finding may raise questions regarding minimum entry requirements for medical school applicants and the development of tolerance of medical uncertainty as future research. Views expressed by the UEMS faculty very close to the curriculum (Chapters 5 and 6) and by medical educators practicing in two UK medical schools with similar curricula design (Chapter 6) were that the social sciences included in undergraduate curricula aided the appreciation of medical uncertainty. However, there were some 'close' faculty who expressed doubt on the value of research methods they perceived as employed within the social sciences, from a perspective of having no direct experience with social science research. But many of the ‘very close’ faculty expressing an opposing perspective also had no direct experience of conducting social science research. This meant that the value of social science research in the development of personal epistemologies regarding medical uncertainty was contested. Lake et al, make the case for including humanities and arts subjects in the undergraduate medical curricula as a means to critique “the dominant technical-rational approach in contemporary medicine” within a “heavily science-based curriculum” and that “the arts can be used to foster creativity and imagination, rather than to develop technical proficiency” (Lake et al, 2015, p.769). Likewise, Monrouxe & Rees argue that a dominant bio-medical model within medical education limits the value that can be gained from theory-driven social science approaches (Monrouxe & Rees, 2009). However, there is still danger that this approach serves to reinforce views that the bio-sciences and ‘other’ topics, such as social sciences/medical humanities/arts have polarised epistemic values, or that creativity, tolerance of ambiguity, cultural and ethical issues sit within the epistemic domain of the non bio-sciences. I do not hold this view point and such views were not shared by the ‘very close’ faculty bio-scientists interviewed during this project. The challenge for policy is in the promotion of the role that bio-scientific knowledge and research adds to the development of personal epistemologies regarding tolerance of uncertainty within medicine, in defiance of current policy trends.

8.6. Strengths And Limitations Of The Research

The methodological design of the thesis took a constructionist and interpretive theoretical perspective with aspects of critical theory to explore the meaning of events and activities as reality that is constructed by individuals and groups. I used qualitative methods (critical discourse analysis, observation of learning episodes, task groups and semi-structured interviews) to put together a case study. The range of methods may appear eclectic, but was intended to capture the complexity of medical education in a rich and thick description, which would not have been so rich and thick if I had used a single methodology, such as by reproducing ‘pen and paper’ questionnaire type data collection used in previous studies on personal epistemology research. The interpretative approach allowed me to be flexible in re-designing or adapting interview questions or when approaching participant groups, searching for counter discourses or exploring aspects of the curriculum that appeared less represented. Activity theory was not used as the overarching theory in the thesis, but it was effective in thinking through and defining the case study contexts, such as close guidance in problem based learning groups, guided learning in clinical placements, limits on development of learning within the curriculum, engagement with work tasks (such as conscious learning for assessments or rejection of learning if not perceived as relevant to assessments), role modelling by 'credible' faculty, which all impact upon medical student judgements about the importance of activities that they engage with. This is influenced by their personal epistemologies. I have been interested in socio-cultural factors as well as curriculum factors that drive such judgements. However, the key research questions concerned curriculum factors. Socio-cultural factors have not been explored widely and this would be an interesting project for future research.

The Foucauldian historical perspective evoked within the critical discourse analysis (Phase 1) noted the ebb and flow of approaching formal standpoints on the nature of science in medicine. My findings indicated that this was a dynamic state, complex and open to possibilities for changing perspectives. In devising a simple model of personal epistemological beliefs from existing theories, this was sufficient to capture where participants, through naturalistic talk and official curricula guidance documents from medical education regulators could be placed at a particular time in terms of models of epistemology regarding the nature of science in medicine. A key finding was that a dominant or 'powerful' discourse regarding science (specifically bio-sciences) as certain and isolated from social constructs is too simplistic an explanation for teaching within the curriculum, in particular to Year One medical students, but that expectations regarding teaching Year One medical students could be influencing the perpetuation of such epistemologies.

Knowledge acquisition and epistemic development makes up a minority of current research in medical education, which is dominated by themes about practitioner skills and behaviours (Rotguns, 2012). This thesis establishes a niche in research within medical education and does not duplicate previous studies. However, the thesis topic is deep and wide. There was a lot to manage. In order to concentrate on rich insights some aspects were pared back to be manageable within the time constraints of a PhD. For example, originally I had intended to present a findings chapter on the observation of learning episodes. From my observations I reached the conclusion that I did not have sufficient data to use to present an entire findings chapter on the observation of learning episodes. Instead I used the observation of learning episodes to inform semi-structured interview guides, reflect upon and present as key findings within other findings chapters and to use as my own learning experiences for iterative reflections upon my personal perspectives as a researcher. Prior to conducting this PhD I had a personal view from my social sciences background of a constructivist and socio-cultural perspective toward the nature of knowledge. My nursing education had been set within a positivist scientific paradigm, but the applied nursing scientific knowledge sat within a strong socio-cultural paradigm, influenced by my years of managing care homes. This led me to question the nature of science within my nursing practice. I had no experience of conducting research outside of social research. Through this PhD and in particular by interviewing the 'very close' faculty, who held PhDs but whom were not necessarily medically qualified, I have let go of any vestigial views of a positivist paradigm regarding the nature of science, hanging over from my nurse training days. I am now in a position to champion the overwhelming similarities between natural/bio-scientific and social scientific research approaches, which I believe share the common themes and approaches of creative enquiry, personal and socio-cultural bias and the tentative nature of knowledge that their research produces.

This thesis is a presentation of my methodological choices, which influenced the project design. I also interpreted the data and mapped findings from my own perspective as middle-aged nurse and social science graduate, therefore the conclusions reached are partial. To add different perspectives on the data collection and to challenge my methodological choices I involved my supervisors in data analysis, invited two peer reviewers in the field of UK based medical education to scrutinise the project design, presented my initial findings to educators at two other UK medical schools and presented parts of the project at five medical education conferences. Likewise, the participants in the project were volunteers and what they said during the data collection phases was in the context of a research interview, which is socially situated. Their responses may have been different depending upon a different researcher, a different time, setting etc. Within the sample of medical student participants there was a significant representation of medical students describing their route into medical school as involving the re-taking of A levels, starting one year of a bio-medical science degree before applying for the course or repeating an early year of the BMBS course due to unsatisfactory grades. Of the 39 medical students interviewed, eight re-sat A levels, three did one year of bio-medical sciences degree and three resat a year of the BMBS course. This may have impacted upon the findings, as students who had tried particularly hard to get into medical school may have been more willing to participate in the study, feeling they had a personal story to share. Their relating of resilience could also affect their perceptions of how they coped with the medical school curriculum.

It was a challenge to recruit the 'distant' faculty, medically qualified doctors who did not hold a contract with the medical school. I recruited three participants, which meant that I presented my mapping of personal epistemological beliefs within this group as tentative. Greater planning for the potential difficulties in approaching and successfully recruiting participants within this group could have made the number of participants commensurate with those within the 'very close' and 'close' faculty groups and given me greater confidence in my findings.

Within the literature review, and use of published research to illustrate and support my thesis generally, there will be literature that I missed or was not manageable to read in the timescales of completing the thesis. For example, I made choices in the critical discourse analysis to look at policy guidance documents from the UK and North America. The choices I made were defended in Chapter 3. But by focusing only on these countries the epistemologies about the nature of science in medicine in other countries and regions of the world has not been considered. However, the discourse analysis was but one element of this research and to have widened the scope would have meant reducing other aspects of the case study. What I have presented is a detailed and nuanced account of undergraduate medical education curriculum at one site, within the context of relevant UK policy guidance.

8.7. Summary Of The Chapter

This chapter has brought together and discussed the findings from Chapters 4 – 7 regarding the scientific content within the BMBS curricula at UEMS/PCMD, statements about scientific approaches within key policy documents and participant perceptions about science and knowledge in the formal, informal and hidden curriculum. I have argued that the thesis methodological approaches were suitable for exploring the research questions, which had overall themes regarding the development of epistemological beliefs situated within the complex and uncertain field of medicine and medical education. The thesis discussion argued that knowing medical student and faculty personal epistemological beliefs are important for the development of the BMBS curriculum content to reach the goal of preparing junior doctors for clinical decision making in practice, which requires sophistication of critical thinking skills.

8.8. Future Research

Within the discussion of my findings I have identified areas for future research. The key areas are as follows;

- Exploring the role that medical students learning social science research methodologies may have in fostering epistemic development. For example, whether more emphasis in curricula regarding bio-psycho-social models of knowledge, which tend to model constructivism and uncertainty, develops greater tolerance of ambiguity in medicine, or whether this remains domain specific.
- Further exploration of whether the more sophisticated personal epistemologies, that seemed to be voiced by medical students who had studied social sciences to at least A level standard (or equivalent) prior to entering medical school, is sustained at graduation, compared with graduate medical students who did not have this background. This may have implications for medical school entry selection processes and future workforce planning.
- Further larger scale exploration of why maturity of age in medical students seemed to be associated with more sophisticated personal epistemological beliefs and types of socio-cultural factors influencing this. To explore whether there is an association, a survey methodology would be appropriate, using a scale for personal epistemology. I do not think that an appropriate tool currently exists tailored to medical students as subjects and suggest development of a new tool. Data from my medical student interviews/task groups and interview schedules/task group exercise would aid in the development of a new scale. I also suggest any new tool be developed by

combining selected questions existing in Lederman et al, 'Views of Nature of Science Questionnaire: Toward Valid and Meaningful Assessment of Learners' Conceptions of Nature of Science' (Lederman et al, 2002).

- Further research to explore the impact on learning when medical students and teachers have more similar or somewhat different epistemologies.

Chapter 9: Conclusion and Recommendations

9.1. Introduction To The Chapter

This thesis has explored the development of medical students' beliefs about the nature of knowledge, particularly scientific knowledge and research evidence, at two time points, representing key transitions, in the undergraduate medical degree. In doing so I have considered influences from the formal, informal and hidden curriculum. I devised two key questions to enable this research;

- What are medical students' beliefs and understandings about the nature of scientific knowledge as applied to medicine?
- What curriculum factors appear to facilitate or inhibit medical students' epistemological development, at key transitions?

New insights were found by conducting this research. These will now be summarised and presented.

9.2. The Contested Curriculum And The Nature Of Science In Competency Based Curricula

In the UK, undergraduate medical education curricula have been contested in terms of topic content for over 150 years. This has reflected both the changing nature of global population health concerns and more recent concerns about professionalism within medicine. Nonetheless, the bio-sciences remain dominant in terms of curriculum and assessment content. Since the second version of *Tomorrow's Doctors*, published in 2003, which introduced competency based curricula, outcomes within the curricula have been more concerned with the application of scientific knowledge, realised as skills, than on a focus with scientific epistemic development and scientific approaches within medicine. Where science in medicine is defined and approaches to scientific research is stated, the formal curricula documents from the regulating body espouse a narrow and positivistic methodological approach, which I have argued serves to perpetuate misconceptions regarding scientific research within medicine, and may influence epistemological beliefs about the nature of science within medicine, in particular with regard to absence of socially constructed and tentative statuses of scientific knowledge. For these beliefs to be challenged formal curricula statements must change.

9.3. Personal Epistemology Similarities And Mismatches

This thesis identified differences in held personal epistemologies regarding science in medicine within and between medical student year groups (Years One and Three), between faculty groups and identified mismatches between medical students and faculty (Years One and 'very close' faculty). There were also strong similarities within faculty groups ('very close' and 'close' faculty). There were also findings suggesting for some groups (most Year One medical students and many medically qualified faculty), that perceived relationships regarding natural sciences and the social sciences in terms of epistemological perspectives were highly divergent. These findings have implications for curricula and teaching, including faculty development and tailoring teaching practices to maximise potential for advancing sophistication of such beliefs for impact upon medical practice. To achieve this, there may be a need for broader faculty recruitment, with partnership expertise from across the University, to support and engender confidence for existing faculty to provide teaching in the range of scientific approaches that contribute richly toward research in medicine.

9.4. The Hidden Curriculum

Role modelling by teaching staff was found to be an important part of the hidden curriculum. There was unanimous feedback from medical students that faculty informally spoke about the ambiguity within medical practice as clinical decision making, but there were very few reports of faculty explicitly speaking about the uncertain and tentative nature of scientific knowledge underpinning applied medicine. Encouragement to faculty to express personal epistemologies about the nature of science as applied to medicine as signposting to medical students in teaching sessions could open up debates and show medical students that a range of views and approaches exist. To facilitate signposting, formal sessions on the nature of science in medicine (including its historical, philosophical, sociological and psychological perspectives) available to faculty and medical students could be a way forward.

Appendices

Appendix 1: Year 1 Medical Students Semi-Structured Interview Question Guide.

1/ How did you get on with the recent AMK exam. Was it what you expected and were there areas that you found difficult? (rationale – students have just taken their first AMK exam and it is high on their radar, they will probably want to talk about this. It will be a good introduction and ice breaker).

2/ How are you progressing? Any course units or skills that are easy or more difficult to get a handle on? (rationale – to see if there are aspects of the curriculum that students already identify as particularly challenging, may indicate what their preconceptions about course content may be).

3/ Background reminder. Courses taken prior to coming to the medical school and any work experience? (rationale - to gain demographic and experiences information, motives for applying to medical school and areas of medicine interests).

4/ Experiences of learning about sciences at school and college. (rationale – to explore prior learning experiences).

5/ How does the experience of learning about scientific methods at UEMS differ from prior learning? (rationale – to explore if students perceive during this transition period different approaches to how science is approached and spoken about, could lead to talking about curriculum structure).

6/ Any questions from the task groups held last term and the card sorting exercise? (rationale – to recap about the exercise to elicit personal epistemologies regarding the nature of science in medicine, leads to Qs 7 - 12).

7/ From the card exercise. What does it mean to apply a scientific method in medicine? How does this differ from a non-scientific method? Such as describing what is scientific about medicine to a lay person. (rationale – personal epistemology).

8/ The transition to medical school. How have any changes of approaches to learning challenged you in thinking about science as applied to medicine? (rationale – curriculum design and epistemological development).

9/ What kind of knowledge does science produce? How certain is this? (rationale – personal epistemology).

10/ What types of teaching approach at Exeter makes you think most about scientific approaches? E.g. lectures, PBL: small group learning, life sciences. Any examples, such as PBL group topics currently under study – explore these? (rationale –curriculum design and personal epistemology).

11/ Have you encountered uncertainty in clinical skill practice or has medicine been talked about on clinical placements as uncertain? (rationale – to encourage discussion of uncertainty within medicine as the application (doing) of science).

12/ Is the science underpinning medicine discussed during clinical placements? How has this been presented (exploring uncertainty). (rationale – to encourage discussion of uncertainty in medicine in the form of scientific knowledge or evidence).

Appendix 2: Year 3 Medical Students Semi-Structured Interview Question Guide.

1/ Can you tell me which A levels or courses you took prior to coming to medical school? Did you have any work experience or paid employment in health care settings? (rationale - to gain demographic and experiences information, motives for applying to medical school and areas of medicine interests).

2/ How are you progressing? Any course units or skills that are easy or more difficult to get a handle on? (rationale – to see if there are aspects of the curriculum that students identify as particularly challenging, may indicate what topics or approaches to research and scientific methods they struggle with and their preconceptions about the course content may be).

3/ How do you find the AMK and other progress exams and are there topics that you find difficult or challenging? (rationale – to see if in discussions around progress tests, what value student read into them, their content and approach – curriculum factors and course content, approaches to learning).

4/ What types of medicine specialities interest you as a result of either the course so far, including clinical placements? Why is this? (rationales – to see if this gives indications re personal epistemologies about science in medicine or if this had changed since entering medical school, lead to a discussion around clinical placements and teaching and learning during placements).

5/ Can you describe your experiences of learning about sciences at school and college? (rationale – to explore prior learning experiences).

6/ How does the experience of learning about science and scientific methods at medical school differ from prior learning? (rationale – to explore if students perceive during this transition period different approaches to how science is approached and spoken about, could lead to talking about curriculum structure).

6/ What are the differences between how you learn about science and evidence as a Year Three student compared to Years One and Two? Is this difficult to adjust to? (rationale – transitioning from mainly university to mainly clinical learning environment, discussion to how science and evidence in medicine is taught and approached, role modelling, science as knowledge or as doing).

7/ Do you have any examples of how science is taught or spoken about on clinical placements, for example by clinicians on wards, GPs or in theatres? How do they discuss with students the evaluation of evidence informing clinical judgements? (rationale – role modelling).

8/ Have clinicians or lecturers spoken about the type of knowledge that science produces, such as whether this is likely to be certain or tentative knowledge? Do you have any views on the nature of scientific evidence from your SSU's? (rationale – personal epistemologies from faculty).

9/ If you were describing what is scientific about the approach to medicine to a lay person what terms would you use? How does this differ from a non-scientific approach and do you consider, for example some types of complementary medicines to be non-scientific? (rationale – personal epistemology).

9/ What kind of knowledge does science produce? How certain is this? (rationale – personal epistemology).

10/ Are there topics in plenaries that are more popular and better attended than others? Have you any examples? (rationale – curriculum content and relative valuing of topics).

11/ At the stage of being in Year Three of the course are there any topics that you think there should be more time devoted to within the curriculum? If so, why? (rationale – curriculum content and personal epistemology).

Appendix 3: Faculty Participant Semi-Structured Interview Guide.

Introduce the topic. This is a qualitative PhD project looking at medical students' beliefs about science and evidence as applied to medicine at key transition points in the BMBS curriculum. It is a case study at Exeter involving interviewing Years 1 and 3 BMBS medical students, observation of learning episodes from the taught curriculum, close reading of key curricula texts and semi-structured interviews with faculty who have teaching input within the BMBS course.

1/ What are your speciality and research interests? (rationale – demographic information)

2/ How long have your taught at UEMS or at PCMD previously? What topics do you teach in the BMBS curriculum? (rationale – demographic information and ice breaker)

3/ Which year groups of BMBS medical students do you teach? (rationale – demographic information and establishing if contact with focus group pf medical students in the study)

4/ Is this PBL/LSRC/clinical skills/lectures? (rationale – establishing aspects within the curriculum)

5/ What sciences do you think Year 1 medical students are expecting to cover in the early years of the curriculum? What makes you think this? (rationale – establishing curriculum and comments upon content)

6/ Do you think this changes as they enter the mainly clinical phases of the course from Year 3? If so, why? (rationale – discussion around curriculum and transition periods with regard to knowledge)

7/ Do you think there are unpopular topics within the early curriculum? If so, why do you think students find these topics off-putting? (rationale – curriculum content and topic valuing – epistemologies about the perceived nature of medicine)

8/ [If yes to Q8] Have you found this attitude changes during Years 3 – 5? (rationale – more about transitions, course content and epistemological development)

9/ Do you think or have you any examples of cohorts/PBL groups with more mature students or those with first degrees when entering medical school having a different approach to thinking about evidence based practice? Do you think this changes by Year 3, for example a levelling of the intellectual playing field? (rationale – differences in personal epistemologies of medical students in terms of maturity, may lead on to other differences in student backgrounds)

10/ Can you tell me about medical student's preparation for clinical placement with you in terms of the science they should research for the placement? Is there a topic guide available for the placement and what does this cover or do you expect medical students to be taking the initiative and self-directed learning? (rationale – curriculum content)

11/ Do you think medical students appreciate and/or feel comfortable with the notion of complexity and uncertainty in medicine? Have you seen any shift from the comments medical students make about uncertainty in medicine from Year 1 to Year 3 students? (rationale – exploring types of uncertainty in medicine, could be as knowledge or application of knowledge)

12/ Do you think medical students have opinion regarding the nature of evidence underpinning medical decision making?/ When might this develop in a medical student? (rationale – nature of science and evidence in medicine)

13/ Do you have a particular view about the nature of scientific knowledge in relation to truth claims in your speciality? (rationale – personal epistemology)

14/ Some medical students have expressed to me that they expected more extensive testing of anatomical and physiological knowledge recall in their formative assessments. Do you think they are right to believe that regular extensive testing of A & P knowledge will make them better doctors? [Please explain your answer]. (rationale – relative valuing of topics, course content and what do doctors need to have knowledge of)

15/ In your experience what do medical students think about how science in medicine is context bound, in relation to ethical concerns, public health agendas, individual patients' views? Does this change during the course? (rationale – the social situated and constructed nature of science and scientific evidence)

16/ Are you involved in BMBS curriculum planning at UEMS? If so, how? Are there topics you would personally like to see more of in the curriculum and if so, why? (rationale- how close to the curriculum are they, and relative valuing of topics)

17/ Have you experienced other types of curriculum, for example the 2:2 model versus UEMS early patient contact, small group learning? If so, do you have a preference and do you think different types of curriculum structure tend to produce graduates with skill sets leaning to particular specialities? (rationale – experiences of differing types of curricula and evaluation of these course designs)

THANK YOU SO MUCH. SAY ABOUT TRANSCRIPTS AND PHD THESIS/PAPERS AND ANONYMITY.

Appendix 4: Medical Student Information Sheet

What types of science count?

Exploring the formal, informal and hidden curricula in undergraduate medical education, with a particular focus on beliefs about science and knowledge.

UEMS REC REFERENCE NUMBER: 14/02/038Δ1

INFORMATION SHEET FOR MEDICAL STUDENTS

VERSION NUMBER 2: DATE 21 July 2014

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate.

What is the aim of the project?

The purpose of the study is to explore medical students' beliefs about the nature of knowledge, particularly scientific knowledge at key transition points in their education.

Description of participants required

We are looking to recruit any Year One medical students enrolled at the University of Exeter Medical School (UEMS) on the Bachelor of Medicine, Bachelor of Surgery programme (BMBS). We also want to recruit any Year Three medical students enrolled at the Peninsula College of Medicine and Dentistry (PCMD) on the BMBS programme.

What will participants be asked to do?

Should you agree to take part in this project, you will be asked to join 5 - 7 other medical students from your year group to discuss science and scientific research. The discussions will be in a task group, so called, as to aid the discussion there will be cards with descriptive words that could be used to portray the properties of science and scientific research. As a group you will be asked to order the cards, drawing on your own experiences at medical school or outside of the medical school, such as in school and college. There will be a PhD researcher based at the University of Exeter who will act as the facilitator in these group sessions.

The task group sessions will take part during the autumn term of 2014 and last approximately 45 minutes. You will be invited to join one task group on one occasion only.

In early 2015 (January/February) some students will be invited to speak with the researcher on a one-to-one basis in a semi-structured interview on the same topic, where the student's individual personal views about science will be further explored. There will be one interview on one occasion, lasting approximately 45 minutes. Therefore the maximum number of times you will be asked to participate is twice; in one task group and in one interview, lasting no more than 90 minutes in total. Task group sessions and individual interviews will be held at the University during lunch times or immediately following teaching sessions when students have free periods.

We do not anticipate you will experience harm or discomfort from volunteering to take part in this project. We hope that by taking part in this project you will find the debate about the nature of science stimulating and thought provoking.

Reward to volunteers/interviewees

We will provide refreshments during the sessions. We will also provide you with a certificate of participation in the project, which you may include as part of your individual learning portfolio.

Can participants change their mind and withdraw from the Project?

You may withdraw from participation in the project at any time and without any disadvantage to yourself of any kind.

What data or information will be collected and what use will be made of it?

We will record group and individual discussions concerning student views and knowledge on the subject of science and scientific research on a voice recorder. We will also ask you to complete a personal details questionnaire providing details such as your age, gender and ethnicity. Details are anonymised. We will use this information to demonstrate the range of people who participated in the study.

This project involves an open-questioning technique where the precise nature of the questions asked have not been determined in advance, but will depend on the way in which the interview develops. Consequently, although the School Research Ethics Committee is aware of the general areas to be explored in the interview, the Committee has not been able to review the precise questions to be used.

In the event that the line of questioning does develop in such a way that you feel hesitant or uncomfortable, you are reminded of your right to decline to answer any particular question(s).

The information is being collected as part of a PhD project. It will be used to address a call for more research within the emergent field of medical education to provide insights into students' epistemological development, any barriers to such and how students can be better supported, notably in transition periods.

We will use data from participant task groups and interviews as part of a PhD thesis. In addition we may use excerpts from the data in presentations at academic conferences and in articles intended for publication in peer reviewed academic journals. Any quotes used in presentations or publications will be anonymised. We are happy to share draft reports and/or publications with the study participants to demonstrate that anonymity has been ensured. The PhD researcher and her supervisors only will have access to the full data.

Results of this project may be published but any data included will not be individually identifiable. The data collected will be securely stored in such a way that only those mentioned above will be able to gain access to it.

Why me?

The project is a case study in Exeter exploring medical students' beliefs about the nature of knowledge, particularly scientific knowledge at key transition points in their education. We are approaching Year One students on the BMBS programme, as entering medical school is one key transition time during the course programme; that of from previous work/education to university. Likewise, students entering their Third

Year on the BMBS programme are transitioning from being primarily university based to being primarily based in healthcare settings.

What if participants have any questions?

If you have any questions about our project, either now or in the future, please feel free to contact either:-

Judith McGregor-Harper	or	Dr. Karen Mattick
Post graduate research student		Associate Professor in Medical Education
The University of Exeter Medical School		The University of Exeter Medical School
St. Luke's Campus		St. Luke's Campus
Heavitree Road		Heavitree Road
Exeter		Exeter
EX1 2LU.		EX1 2LU.
j.l.mcgregor-harper@exeter.ac.uk		K.L.Mattick@exeter.ac.uk

Complaints

If you have any complaints about the way in which this study has been carried out please contact the Chair of the University of Exeter Medical School Research Ethics Committee:-

Peta Foxall, PhD. Chair, UEMS Research Ethics Committee

Email : P.J.D.Foxall@exeter.ac.uk

This project has been reviewed and approved by the

University of Exeter Medical School Research Ethics Committee

Appendix 5: Faculty Information Sheet.

What types of science count?

Exploring the formal, informal and hidden curricula in undergraduate medical education, with a particular focus on beliefs about science and knowledge.

UEMS REC REFERENCE NUMBER: 14/02/038Δ.

INFORMATION SHEET FOR UNIVERSITY OF EXETER MEDICAL SCHOOL (UEMS) and PENINSULA COLLEGE OF MEDICINE AND DENTISTRY (PCMD) FACULTY TEACHING STAFF

VERSION NUMBER 2: DATE 21 July 2014

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate.

What is the aim of the project?

The purpose of the study is to explore medical students' beliefs about the nature of knowledge, particularly scientific knowledge at key transition points in their education. In addition, the study necessitates an understanding of the taught course content of the Bachelor of Medicine, Bachelor of Surgery (BMBS) programme.

It is anticipated that outcomes from the study will provide insight into how and when educators need to intervene to improve student epistemological development, in order to nurture professionals who are capable of complex decision making.

Description of participants required

We are looking to recruit 'front line' teaching staff at UEMS/PCMD.

What will participants be asked to do?

Should you agree to take part in this project, you will be invited to speak with the PhD researcher on a one-to-one basis in a semi-structured interview about the taught scientific content within the BMBS programme and your views on the nature of scientific knowledge. You will be asked to attend one interview on one occasion, lasting approximately 45 minutes. The interviews will be scheduled from January 2015 onwards during term time.

We do not anticipate you will experience harm or discomfort from volunteering to take part in this project. We hope that by taking part in this project you will find the debate about the nature of science stimulating and thought provoking.

Reward to interviewees.
We will provide refreshments during the sessions.

Can participants change their mind and withdraw from the Project?

You may withdraw from participation in the project at any time and without any disadvantage to yourself of any kind.

What data or information will be collected and what use will be made of it?

We will record the individual interview discussions using a voice recorder.

This project involves an open-questioning technique where the precise nature of the questions asked have not been determined in advance, but will depend on the way in which the interview develops. Consequently, although the School Research Ethics Committee is aware of the general areas to be explored in the interview, the Committee has not been able to review the precise questions to be used.

In the event that the line of questioning does develop in such a way that you feel hesitant or uncomfortable, you are reminded of your right to decline to answer any particular question(s).

The information is being collected as part of a PhD project. It will be used to address a call for more research within the emergent field of medical education to provide insights into students' epistemological development, any barriers to such and how students can be better supported, notably in transition periods.

We will use data from participant task groups and interviews as part of a PhD thesis. In addition we may use excerpts from the data in presentations at academic conferences and in articles intended for publication in peer reviewed academic journals. Any quotes used in presentations or publications will be anonymised. We are happy to share draft reports and/or publications with the study participants. The student researcher and her supervisors only will have access to the full data.

Results of this project may be published but any data included will not be individually identifiable.

Why me?

We want to interview front line teaching staff at UEMS to discuss the taught scientific content in the BMBS programme, and to explore any differences between the curriculum on paper and the curriculum as received by students.

What if participants have any questions?

If you have any questions about our project, either now or in the future, please feel free to contact either:-

Judith McGregor-Harper or Dr. Karen Mattick

Judith McGregor-Harper	Dr. Karen Mattick
Post graduate research student	Assoc Prof. in Medical Education
University of Exeter Medical School	University of Exeter Medical School
St. Luke's Campus	St. Luke's Campus
Exeter	Exeter
EX1 2LU.	EX1 2LU.
j.l.mcgregor-harper@exeter.ac.uk	K.L.Mattick@exeter.ac.uk

Complaints

If you have any complaints about the way in which this study has been carried out please contact the Chair of the University of Exeter Medical School Research Ethics Committee:-

Peta Foxall, PhD. Chair, UEMS Research Ethics Committee.

Email : P.J.D.Foxall@exeter.ac.uk

This project has been reviewed and approved by the

University of Exeter Medical School Research Ethics Committee

Appendix 6: Research Ethics Approval Document.

University of Exeter Medical School
Research Ethics Committee

Certificate of Ethical Approval

Research Institute/Centre: Clinical Education

Title of Project: What types of science count – Exploring the formal, informal and hidden curricula in undergraduate medical education with particular focus on beliefs about science and knowledge

Name(s) of Project Research Team member(s): Judith McGregor-Harper, Dr Karen Mattick, Dr Keith Postlethwaite

Project Contact Point: Judith McGregor-Harper

This project has been approved for the period

From: **November 2014***

To: **November 2016**

*Interim approval for student element of this project granted 02 October 2014
Approval for staff element granted 07 November 2014.

University of Exeter Medical School
Research Ethics Committee approval reference: Nov14/B/038Δ1

Signature:

Date: 07 November 2014

Name of Chair
Peta Foxall, PhD

Your attention is drawn of the attached paper "Guidance for Researchers when Ethics Committee approval is given", which reminds the researcher of information that needs to be observed when Ethics Committee approval is given.

Application Reference Number 14/02/038Δ1

Appendix 7: Example Of A Participant Transcript

N/B Only the first two pages are presented in order to show the transcript formatting and to protect the confidentiality of the participant involved, who may be identified by the content of the transcript if presented in its entirety.

Qualitative Interview Transcription

Participant	F114 Name of document – F114 03 Feb 2015 interview.mp3
Interviewer	JM
Date of interview	03/02/2015
Mode of interview	In person
Transcribed by	Anthea Asprey
Date last modified	30/06/2105
Transcript checked by	Insert name of person who checked transcript and date check completed

Transcription conventions:

{} Interviewer and participant talk at same time
[] non-verbal utterances e.g. laughter
??? unintelligible – and indicate place on the recording in minutes and seconds.
(…) pause
Hyphen indicates an abrupt cut off or self-interruption
Italics indicates emphasis on the word

JM:

So we are Tuesday 3rd February and we're in Cloisters and I'm here with X who's a first year medical student who attended one of the group sessions last term. And the thing I want to start with is how did you find AMK the other week?

F114:

Oh it was – I thought it was better than the last one that I gave in November, obviously I haven't had the results yet but – but it's just having the questions come on the screen that you won't know, I think that's quite a daunting experience because you're not meant to know everything, and it's the first time you're kind of going into something since – like in school you have A level exams but you're revised everything and you've done revision whereas for the AMK no matter how much you do it's never going to be able to fulfil – to answer all those questions. So that's quite hard. But it was better than last time, I think that's – 'cause we've done one before now, so ….

JM:

And the type of scenarios that came up, were you expecting some of them at all? I mean, had you had a chance to speak to the second year mothers and fathers you get, or something, isn't it?

F114:

Yes, yes we spoke to them and it's very much – they always say that you will get some stuff that's based on something you're studying, but it's not always the case. And it's just about – if you can narrow down your answers from, like, prior knowledge or what you may have read during the course and going to, like, extra lectures and stuff, but it's just – it's one of those fifty, fifty – sometimes it goes that fifty-fifty option and you just need to make a decision and it's that negative marking option that's quite – I think if there wasn't that you could just go and guess everything it would be much easier. It's about deciding which questions you could do and which ones you can't, definitely do and then it's like quite statistically you have to work it out and it's quite hard to know.

JM:

And which special study unit did you get allocated?

F114:

For this time I've got introduction to psychopathology. So it's the biomed, so it's quite interesting but my session got cancelled yesterday so I don't know what it's quite on yet, so … not sure what we're going to have to do.

JM:

And because with the SSUs, isn't it, you sort of – you get a choice in which order you want to do the SSUs, isn't it, but you do eventually have to …

F114:

You do all of them.

Appendix 8: Working Document For Data-Led Thematic Analysis Codes.

Working Data-Led Thematic Analysis Codes (version 6)

1.0	**NATURE OF SCIENCE (personal epistemology)** Under this theme we have coded participant's individual beliefs about science and scientific knowledge. In general, the nature of science refers to key principles and ideas which provide a description of science as a way of knowing, as well as characteristics of scientific knowledge.
1.1	**AUTHORITATIVE KNOWLEDGE** In this sub-theme we have coded participants discussing science and scientific knowledge in terms of authoritative knowledge, such as knowledge from experts or supervisors including specific truth claims about the nature of scientific knowledge in their subject area and whether this is to be understood as accurate, true and reliable.
1.2	**SUBJECTIVE/OBJECTIVE** In this sub-theme we have coded medical students discussing science and scientific knowledge in terms of degrees of subjectivity and objectivity, such as in relation to truth claims or scientific methodological approaches.
1.3	**CONSTANT/CHANGING** In this sub-theme we have coded medical students discussing science and scientific knowledge in terms of constancy; such as scientific approaches as unvarying or scientific knowledge as fixed and unchanging, or the view of science and scientific knowledge as changing, such as by having transitive properties in terms of knowledge or technical advancement.
1.4	**SCIENTIFIC AND NON-SCIENTIFIC METHODS** In this sub-theme we have coded participants discussing science in medicine as a theoretical activity and their perceived attributes and approaches toward what scientific and non-scientific methods might be.
1.5	**SCIENTIFIC KNOWLEDGE FOR APPLICATION INTO PRACTICAL TASKS** In this sub-theme we have coded participants talking about

	science spoken about at medical school as an applied ‘doing’ activity. This includes medical students describing their contact with faculty academics employed by the medical schools and with clinicians on clinical placements in relation to how role models talk about science as it relates to medicine.
2.0	**THE NATURE OF MEDICINE** In this theme we have coded whether medicine is perceived to be a scientific discipline and what might make medicine scientific.
2.1	**MEDICINE AS AN SCIENCE** In this sub-theme we have coded participants discussing medicine in terms of whether medicine shares more similarities with the sciences than the arts and what differences there are between arts and sciences.
2.2	**MEDICINE AS AN ART** In this sub-theme we have coded participants discussing medicine in terms of having more attributes common to the arts than sciences and the similarities and complimentary attributes that are found in the two approaches.
2.3	**UNCERTAINTY IN MEDICINE** In this sub-theme we have coded participants talking about their experiences of encountering medical uncertainty.
2.3.1	**Clinical or diagnostic uncertainty** In this sub-heading we have coded participants discussing uncertainty as deriving both from a lack of technical knowledge and a lack of clinical experience/judgment. This includes uncertainty about the diagnosis and cause of illness, diagnostic uncertainty in the absence of necessary test results and uncertainty in terms prescribing decisions.
2.3.2	**Process based uncertainty** In this sub-heading we have coded participants talking about uncertainty expressed as familiarity with work based processes and systems, such as ordering, requesting and receiving clinical tests, using the local paper-based/electronic systems and local policies and procedures.
2.3.3	**Communicating uncertainty** In this sub-heading we have coded participants talking about how they would find expressing uncertainty about medical practice or

	scientific knowledge as it relates to medicine, either to peers, tutors, clinicians or patients.
2.3.3.1	***Feeling comfortable with one's own limitations of knowledge*** In this sub-sub-heading we have coded theme participants talking about the limitations of their knowledge in relation to scientific knowledge in medicine. Participants express feelings of being secure with their limited knowledge of medicine and that their knowledge may always be partial.
2.3.3.2	***Feeling uncomfortable with one's own limitations of knowledge*** In this sub-sub-heading we have coded participants expressing feelings of being ill at ease with their limited knowledge of medicine and seek to find alternative solutions to promote certainty in their clinical practice.
3.0	**EXPERIENCES OF EDUCATION** Under this theme we have coded participants' reflections upon their experiences of education, whether as students or educators.
3.1	**PRIOR TO THIS MEDICAL SCHOOL** In this sub-theme we have coded participants' describing their learning experiences of taught topics and experiences of exposure to medicine/health related disciplines before they entered medical school.
3.1.1	**Conceptions of learning** In this sub-heading we have coded participants' reflections upon broad conceptions of learning approaches experienced before coming to the medical school.
3.1.2	**Nature of the curriculum** In this sub-heading we have coded the nature of the curricula participants have experienced previously. Participants talk about structured curricula, designed around specific subject areas related to exams and assessment processes.
3.1.2.1	***Approach to assessments*** In this sub-sub-heading we have coded participants describing

	how they approached learning for assessments.
3.1.2.2	***Memorising and reproducing information for exams*** In this sub-sub-heading we have coded participants' reflecting on the technique of memorising and reproducing information for the purpose of passing assessments during courses.
3.2	**AT THIS MEDICAL SCHOOL** In this sub-theme we have coded how participants describe experiences of learning at this medical school.
3.2.1	**Self-directed learning** In this sub-heading we have coded participants talking about *self-directed learning* (SDL); where the individual takes the initiative and the responsibility for what occurs to select and manage their own learning.
3.2.1.1	***Self-directed learning – positives*** In this sub-sub-heading we have coded participants' talking about SDL as a learning approach experience in positive terms, such as a way of engendering deeper knowledge acquisition compared to pre-medical school learning styles.
3.2.1.2	***Self-directed learning – negatives*** In this sub-sub-heading we have coded participants' talking about SDL as a new learning approach experience in negative terms, such as feeling overwhelmed with the choices involved in locating information from a variety of scientific and academic sources.
3.2.2	**Reflective learning** In this sub-heading we have coded where medical students assess their own *learning* activities within the course. Participants talk about their perceptions of the depth of knowledge and learning required to succeed on the course.
3.2.2.1	***Reflective learning – positives*** In this sub-sub-heading we have coded medical students talking about encountering reflective learning as a positive and reassuring experience.
3.2.2.2	***Reflective learning – negatives*** In this sub-sub-heading we have coded medical students talking

	about encountering reflective learning as a difficult or anxiety inducing experience.
3.2.3	**Assessment** In this sub-heading we have coded participants' reflecting upon exams and other types of assessments they have experienced in the course.
3.2.3.1	***Perceptions of the types of knowledge that are assessed*** In this sub-sub-heading we have coded participants' reflecting upon the types of knowledge that will be assessed in exams and assessments, such as broad or specific understanding of medical and scientific concepts and human biological systems.
3.2.3.2	***Using taught knowledge in an exam passing strategy*** In this sub-sub-heading we have coded participants talking about strategies for succeeding in assessments by making choices about what types of medical and scientific knowledge to concentrate upon or cast aside in order to maximise exam or assessment scores.
3.2.4	**Course pace and structure** In this sub-heading we have coded participants reflecting on the structure and pace of the BMBS curriculum.
3.2.4.1	***Pace of the course*** In this sub-sub-heading we have coded medical students specifically talking about how the pace of the course at medical school compares with prior learning and any contrast in how this poses a challenge to their perceived effective learning and knowledge fulfilment.
3.2.4.2	***Structure of the course*** In this sub-sub-heading we have coded participants specifically reflecting upon curricula structure at medical school, compared with other experiences.
3.2.5	**Early clinical placements** In this sub-heading we have coded participants discussing their experiences of clinical placements occurring in the first year of the BMBS course.
3.2.6	**Early patient contact**

	In this sub-heading we have coded participants discussing their experiences of patient contact occurring in the first year of the BMBS course.
3.2.7	**Small group learning** In this sub-heading we have coded participants discussing their experiences of small group learning within the medical school curriculum.
3.2.8	**Topic coverage** In this sub-heading we have coded participants talking about the topics that are covered in the BMBS curriculum.
3.2.8.1	***Curriculum subject relative valuing of medical students*** In this sub-sub-heading we have coded medical students talking about their own sense of relevance of curriculum subjects in terms of relevance to medicine.
3.2.8.2	***Curriculum subject relative valuing of teaching staff/clinical staff*** In this sub-sub-heading we have coded faculty/clinical staff explicitly expressing relative valuing views about topics covered in the BMBS curriculum in relation to science and medicine.
3.2.8.3	***Curriculum subject bias inferred by medical students*** In this sub-sub-heading we have coded medical students' views where they perceive if faculty/clinical staff hold bias toward/against topics/subject areas and on what basis this is explained in terms of supporting the development of scientific knowledge in medicine.

Appendix 9: Medical Student Participant Demographic Data.

Year One And Year Three Medical Student Participant Self-Declared Ethnicity

Ethnic origin by the Higher Education Statistical Agency coding – www.hsea.ac.uk

Self-Declared Ethnic Group	Year One Medical Students (n = 25)	Year Three Medical Students (n = 14)
White British	18	9
Any other White background	2	
Asian (Indian)	1	1
Asian (any other Asian background)		3
Black (African)	1	1
Black (Caribbean)	1	
White and Asian	1	
Chinese	1	

Years One And Year Three Medical Student Participant Self-Declared Home Base When Not At Medical School

Home base	UK	Other EU country	Non-EU country
Year One Medical Students (n = 25)	21	1	3
Year Three Medical Students (n = 14)	14		

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