# The Case for Genomics: Introducing Elements of Emerging Science Research into Curriculum

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Doctor of Philosophy

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***Declaration:***

I, **Teremun Franklin-Jibri Rider**, confirm that the work presented in my thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

# Abstract

Curriculum development can be seen as playing a key role in determining what aspects of culture are suitable for preparing upcoming generations through schooling. While literature reveals much about curriculum development as a process, there is still a growing need to study how newly developed knowledge is selected and transformed for purposes of teaching and learning. Using the introduction of genomics into the National Curriculum of England as a basis, the current study sought to examine the processes that transform newly developed scientific research into what is taught in secondary science courses. This focused on studying how genomics knowledge came to be introduced into the National Curriculum for England and what that may reveal about the processes that are responsible for selecting and transforming newly developed knowledge into curricula and secondary science lessons. Semi-structured interviews were conducted with eight individuals, each with experience in the development of science curricula and science lessons for secondary courses, to explore how genomics knowledge was eventually introduced into secondary science courses through professional learning and science curricula. Employing Bernstein's Pedagogic Device as a lens, thematic and discourse analyses were used to examine how genomics knowledge was selected and transformed from research science into pedagogic communication such as the National Curriculum and exam specifications. Analysis connected the desire to introduce elements of genomics knowledge into secondary science courses to efforts by several linked organizations within both the public and volunteer sectors to prepare secondary science students as prospective consumers of and contributors to potential genomics-based medicine resulting from the mapping of the human genome. The intermingling of government and non-government influences on science teaching is not new but requires greater scrutiny as these relationships extend further into educational policymaking. This holds implications for the study of curriculum as the theoretical boundaries between the production, recontextualisation, and reproduction of new knowledge become harder to distinguish as numerous organizations continue to seek influence in what is taught in science courses. This may require re-examination of the ways we study the selection of knowledge deemed appropriate for schooling through the development of curriculum.

## Impact Statement

The findings of this study have potential impact both within and outside of academia. As more groups outside the traditional field of science education continue to seek influence on what is taught in science courses to impact social causes, there is an increasing need to understand the role non-education organizations play in both recontextualising science knowledge for science educators and the levels of influence they wield in the various processes that determine what science students are meant to be learning.

In the field of curriculum development there is discussion about how the theoretical aligns with practical policymaking. While emerging frameworks explore how modern cultural changes are affecting what we deem appropriate for secondary students to learn, the results of my study may provide a new lens for viewing how organizations can contribute new ideas and concepts to this change. If such organizations outside the traditional spheres of education continue to try to affect aspects of society through curriculum, then my research may provide an additional framework for studying how the interactions between public and non-governmental organizations of the voluntary sector entities can drive cultural decisions through shared interests and reach. My research has the potential to impact both curriculum researchers and policymakers as they continue to evaluate what aspects of new knowledge are appropriate for future students and their lives past secondary schooling.

In the field of science education research, my work provides insight into the processes that transform newly developed research into pedagogic communication such as curriculum documents, textbooks, and teacher resources. The increasing link of science education and social issues, such as climate change and the ethics of food production, will likely facilitate the need for understanding how science teaching influences and affects cultural values and vice versa. As such, there is potential for my research to impact not only science education academia but also those seeking to impact societal knowledge through schools. This includes impacting non-government organizations and science outreach and communication organizations by providing a framework for integrating socially relevant material into science courses.

The impact of my work also stretches beyond theoretical research. Curriculum is a product of policymaking processes at numerous levels and this study provides a lens for interpreting how these decisions are made and the interactions that lead to them. As governments continue to partner with non-government organizations and others to develop policy, my work could serve as an indicator of what those relationships look like and the factors that facilitate them. This stands to impact policymakers and the relationships they seek.

## *Dedication*

*To the memory of Vernon L. Rider. A loving father, a brilliant educator, and the greatest science teacher I never had.*

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Firstly, I would like to thank my participants. Without their involvement this study would not have been possible. Their willingness to express their ideas and experiences make up the backbone of this study and to them I am very grateful.

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# Chapter 1: Introduction

Curriculum plays an important role in secondary education. Frequently described as the organization of knowledge deemed important for all students, it often forms the basis for what is taught in classroom (Glatthorn et al., 2006; Prideaux, 2003). Consequently, curriculum often holds significant implications for society (Scholtz, 2016). The taught curriculum in compulsory education can be seen as representing the knowledge and skills deemed important enough for members of society. As society changes, so does the critical knowledge needed to prepare students. This can be important in the sciences as what is learned in secondary school often represents the foundational basis for how many members of society understand and interpret science knowledge (Lazarowitz & Bloch, 2005; Stuckey et al., 2013).

As access and exposure to scientific knowledge becomes more prevalent through news organizations and platforms such as social media, there has been a steady but growing call for shifts in secondary science teaching from focusing on science as accumulated knowledge towards the processes of scientific inquiry (Millar & Osborne, 1998; Oates, 2011). This desire has been based upon the idea that science teaching should be having a greater effect on society outside of the classroom (Tidemand & Nielsen, 2017). By emphasizing science teaching based on developing student ability to “think scientifically”, it is argued that science educators can better prepare students for future interactions with scientific information later in life. The need for such a shift can be seen in responses during the Covid-19 pandemic where researchers have noted how the transfer of information from the scientific community to policymakers and from policymakers to the public are often influenced by different forms of media (Cuello-Garcia et al., 2020; Van Dijck & Alinejad, 2020). It can be speculated that the passage of scientific information today is less a straight line from trusted source to the public and more akin to a web that requires some level of scientific understanding to decipher.

This shift has been occurring in classrooms and has had some effects on the way we prepare to teach students to interact with scientific knowledge past secondary schooling (Machluf et al., 2017). As this shift in science teaching becomes more prevalent, organizations not traditionally associated with the development of science education resources and classroom practices are seeking to have greater influence on the processes that determine what knowledge is suitable for teaching in science courses.

Newly emerging technologies often lead to advancements in science and science research and as new knowledge becomes available, questions form about its place in modern science teaching and the role it is meant to play in the post-secondary lives of students. As this process continues, more information needs to be gleaned, about not only the processes by which knowledge is deemed appropriate for teaching in secondary science courses, but also how said knowledge is converted from a science research discourse to a discourse based in science education and beyond. This is the goal of the current study.

As the current study seeks to explore how emerging scientific research becomes a part of the curriculum and lessons taught in secondary science courses, the subject of genomics made sense as a point of interest. The United Kingdom (UK) as a whole has a strong history of supporting and contributing to genetics and genomics research (Ashelford, 2008; Muñoz et al., 2016). As the current National Curriculum for England (DfE, 2013a, 2014) contains specific references to genomics that were not included in the previous iterations, it can be inferred that the most recent revision processes played a role in its introduction. Exploring the processes that saw genomics knowledge introduced into the National Curriculum creates a unique opportunity to investigate how research science sometimes becomes the knowledge taught in secondary science courses and the processes that convert it.

## 1.1 Context of the Study

The current study was conducted within the context of the English compulsory schooling system and the associated National Curriculum. Established by the 1988 Education Reform Act, England's National Curriculum has provided a basis for the development of pedagogic resources such as textbooks, teacher resources, and exams for over three decades (Fowler, 1990; Whetton, 2009; Woodhead & Dainton, 1996). The National Curriculum specifies what knowledge and skills should be taught from ages 5-16 in schools. While schools can be exempted from teaching the National Curriculum, exams and qualifications are often based on skills and content from the National Curriculum for each subject area.

England has made important contributions to research endeavors such as the Human Genome Project and has spearheaded efforts such as the development of the UK Biobank (Campbell & Nehm, 2013; Gericke & Smith, 2014). These contributions had numerous impacts on a number of organizations such as the Wellcome Trust and programs such as the Nowgen Schools Genomics Programme. As the study sought to examine how newly emerging research in science becomes what is meant to be taught in secondary science courses with an emphasis on genomics, exploring England's eventual inclusion of genomics into the National Curriculum's KS4 programme of study (Science PoS) (DfE, 2014) provided a unique and potentially insightful opportunity.

## 1.2 Structure of the Thesis

Following this introductory chapter, I will outline the basis for this study in the literature, the methodological and theoretical approach I employed in collecting and analyzing data, the findings, and the implications for further study. Chapters 2, 3, 4, and 5 will constitute my review of the literature. In Chapter 2, I will review curriculum development as both a theoretical basis for determining what knowledge is suitable for society and a practical process of policymaking and define the research questions of the study. In Chapters 3 and 4, I will focus on the history of genetics with the former delving into its development as a research science and the latter focusing on its teaching in secondary science courses in England. In Chapter 5, I will review the theoretical tools that could be used to examine the processes that transform knowledge into pedagogic communication, critiquing each for their appropriateness in the current study.

Chapter 6 will focus on my methodological approach. I will outline my methods for recruiting participants and the collection, organizing, and coding of data. Chapter 7 will be devoted to defining how I applied the theoretical approach to the analysis of collected data and what they revealed. Chapter 8 will detail the findings and processes used to develop them from analysis of the data through highlighted themes and application of the theoretical lens.

Chapter 9 represents a comparison of my findings with those of others in the field. I will delve deeper into what the introduction of genomics knowledge into the National Curriculum's Science PoS (DfE, 2014) reveals about how new knowledge is transformed into pedagogic communication. I will also explore where my findings sit within the field of curriculum development, specifically within the area of how new scientific knowledge is selected for teaching in secondary schools.

In Chapter 10, I will summarize the study and its implications for the field of academia and beyond. I will also review the limitations of the study and how further researchers may extend this work.

# Chapter 2: Curriculum, Policy, and Classrooms

Initially, the goal of the current study was to explore how genomics knowledge came to be integrated into the National Curriculum for England's Science PoS (DfE, 2014) and what that might reveal about how newly emerging scientific knowledge developed in research centers becomes what is taught in secondary school science courses and the organizations and individuals that influence the process. Achieving this goal requires examining past explorations and studies into the subject of curriculum development as both a theoretical (academically studied) and practical (policymaking) exercise. Exploring this subject also requires delving into the history of genetics and genomics as both a research science and subject of science teaching. In this chapter and the following three I will examine what the literature reveals about these key areas.

In this chapter, I will examine some key concepts centered on curriculum. Firstly, I will examine the history of the National Curriculum in the United Kingdom. Giving some insight into the National Curriculum will be very important when discussing how the most recent revision (and the stages leading up to it) of the National Curriculum's Science PoS (DfE, 2014) came to include genomics. As the goal is to better understand how new knowledge becomes pedagogic communication in the form of curricula, providing some insight into the initial creation of the National Curriculum can help to illuminate how the processes of its development have evolved.

Secondly, I will outline some general ideas of curriculum and the way it is studied and viewed. Outlining key principles on how curriculum is defined, developed, and studied from a research standpoint will help foreground many of the processes that shape its creation. This will focus on the interplay of curriculum and its impact on society.

Thirdly, a basic process of educational policy development will be outlined. As stated previously, the development of the National Curriculum can be viewed as an act of policymaking led by Government and civil servants. Developing a model of educational policymaking will help to outline a general process to compare the examined case with. This information can be important when considering the roles of the various individuals involved in educational policy creation and implementation.

Lastly, a more nuanced view of curriculum development will be discussed. It is important to note while a general approach to educational policymaking can be outlined, the actual process itself can be much more complicated. To better gain an understanding of how these processes occur in reality, this chapter will also include an exploration of what the actual processes of curriculum development entail. Examining these processes will help to outline the realities of introducing new concepts into curricula.

## 2.1 A Brief History of the National Curriculum

The National Curriculum was first introduced to England, Wales, and Northern Ireland following passage of the 1988 Educational Reform Act (Whetton, 2009). The act, an undertaking of the then Conservative government led by Margaret Thatcher, laid out a series of policy changes in education which sought to place education more in the hands of localities as opposed to the government and create an "educational market" through open enrolment and local-based management of schools. According to Woodhead and Dainton (1996), the Government felt combining these concepts with a pupil-based funding would require schools to "compete" for pupils, increasing performance through free market principles.

Though it would seem that creating a National Curriculum would be at odds with their stance of education being a matter of local governance as opposed to national, the government of the time considered it to be a centralizing factor around which competing schools were to be united (Lee, 2013). It also provided, through forms of assessment that could be published, a way in which parents could compare schools, fueling competition within the educational market. It has also been posited that the National Curriculum was seen as an opportunity to filter government positions on education down through quasi-state bodies and into schools (Ball & Bowe, 1992).

The 1988 Educational Reform Act (ERA) established a government-sanctioned curriculum for pupils aged 5-16 (Whetton, 2009). The curriculum was to be split into Core subjects, consisting of mathematics, science and English, and Foundation subjects consisting of technology, history, geography, foreign languages, music, art, and physical education. The ERA also established a means of assessing students at a number of key ages for their proficiency of skills and their knowledge. To monitor schools' progress in meeting these reforms, the Office for Standards and Education (OFSTED) was also established. These changes would not go into effect immediately but would eventually be phased into the educational system after years of consultation (Fowler, 1990).

The reforms outlined above represented quite a change in education in England and Wales (Roberts, 2021). Prior to the ERA, teachers had a relatively independent role in the creation of their curriculum. Now the government would play a huge role in determining what was taught in classrooms.

Of course, these reforms do not occur in a vacuum. As with much policy, the reforms outlined above can be said to be a product to the political and historical climate in which they were formed. Education policy is no different and understanding the policymaking environment can help to better contextualize the products developed from it.

Bell (1999) characterizes educational policy creation, during this period, as part of four policy stages. The first two of these stages help us to lay the scene for the educational policy work that would follow. He refers to the period from 1960-1973 as the Social Democratic Phase and characterizes this stage as emphasizing strong growth in the profession with teachers having considerable amounts of autonomy in regard to curriculum. There is little resource management and also very little conflict between interest groups.

This is followed by what he calls the Resource Constrained Phase (1973-1987) and its emphasis on the management of school economics and finances. This period would see significant amounts of scrutiny placed on the financial aspects of compulsory schooling (Fowler, 1990; Whitty, 1990). As questions are raised about the financial model of the educational system in England, discourse also begins to develop about the nature, purpose, and control of said system. Leaders both within and outside of the political sphere begin to question who controls the resources utilized in educating youth and what systems are in place to ensure quality teaching is occurring. As this is quite a shift from the Social Democratic Phase it is no surprise reforms would be on the horizon in the form of the Education Reform Act (ERA).

The genesis of this shift can be linked to many factors. Guthrie and Pierce (1990) theorized that a burgeoning international economy played a role. They posit that educational reform in England during the 1980s can be traced to the need for a more highly educated workforce leading to a desire to increase the quality of compulsory schooling and the expansion of its access.  Brown (1990) theorized that what actually was occurring was a move towards an educational system whereby the education a child receives must conform to the wealth and wishes of parents rather than the abilities and efforts of pupils. Demaine (1988) attributes changes to a desire of the Conservative Party to privatize education through the guise of improving schools through market forces. It is of note that each of these views posits some form of market competition as being the solution to the perceived problems of education found within the country. During this period Thatcher holds significant roles as the Education Secretary, Leader of the Opposition Conservative party, and eventually Prime Minster. It can be stated that this shift is very much reflective and the product of her views of education, particularly those on empowering parents through school choice (Bailey, 1995; Ku, 2022).

The extent to which this was successful has been debated. Barker (2008) notes that reforms in education tied to marketization have yet to conclusively yield positive results and has possibly contributed to greater amounts of inequality in the educational system. Gorad et al (2002) made links between the market approach rising levels of segregation by poverty. Hoskins (2023) ties the act to inequality in student body composition in several higher education institutions across England.

As part of the ERA, the National Curriculum was meant to centralize efforts surrounding education by setting a common criterion by which schools could be evaluated and compared. To an extent, this role of the National Curriculum continues today. Although no longer mandatory in all schools, the National Curriculum does continue to form some basis for classroom instruction, the development of national exams, and the creation of classroom materials and lessons (Lee, 2013; Roberts, 2014; Woolley, 2019). As such, its development continues to play a pivotal role in education and is worthy of examination, as are those with the power to influence the process. The development of the National Curriculum can be considered an act of policymaking carried out by actors and like any other act of policymaking, is susceptible to systems of power involving politics and culture amongst many other things (Ball, 2015; Braun et al., 2010; Kwok, 2022).

As new discoveries are made and the National Curriculum continues to grow, it is important to consider the processes by which newly developed knowledge is weighed and considered. It also important to consider how the process is influenced by those participating.  The current study looks to explore how the influence of these forces affects the introduction of new knowledge into the curriculum through various actors or players.

## 2.2 Curriculum, Culture, and Society

The curriculum can be viewed through several different lenses (Kelly, 2009; Klein, 1992; Lau, 2001). Defining the term can be quite difficult. For the current study two viewpoints can be considered. Some prefer to view curriculum as a document, a very specific product with a very specific role in education practice. Neagley and Evans (1967) define curriculum as the planned learning experiences provided by schools so that pupils may obtain specific learning outcomes. In their view the curriculum is a document with specific purposes in education.

Others tend to define curriculum in connection with processes of socialization and the defining of culture. Beauchamp (1982) describes the curriculum as the product of the organization of goals and culture content arranged to reveal a potential progression through levels of schooling. According to this viewpoint, the curriculum represents the knowledge and skills deemed culturally appropriate for members of society. This represents a different view from Neagly and Evans as it emphasizes societal impact as opposed to just learning outcomes. With the introduction of the word "culture", this view sees curriculum as a means of embedding aspects of culture into pupils through schooling. The study of curriculum and curriculum theory seeks to consider the role of curriculum development in education and beyond. As such, the study of curriculum theory involves looking at the curriculum as related educational concepts that provide a systematic and illuminating perspective of curricular phenomena in addition to the role it plays in socialization (Glatthorn et al., 2006). As such, curriculum addresses academic content such as math and science knowledge but also how that content interacts with social ideas and values.

So how are both factors explored in the study of curriculum? Ellis (2014) offers three models for orienting curriculum, each offering different foci. According to Ellis, a learner-centered model emphasizes curriculum as seeking to meet the needs and interests of the learner, the society-centered model focuses on developing the student as a potential member of society, and the knowledge-centered model highlights the knowledge that is seen as valued. Ellis does highlight that while one model can be dominant, most curriculum documents typically contain aspects of all three (Ellis & Fouts, 2001).

This influence of society and culture on curriculum is prevalent within the literature (Apple, 2018; Barrett & Rata, 2014; Doll Jr, 1993). Society and culture are linked and are often considered in tandem with regard to compulsory education and beyond. Erstad and Voogt (2018) note that while the two are linked, social changes can occur quickly while curriculum development is a slower process. This can result in a misalignment of what is meant to be taught in school and social values. Lawton (2012) also recognized the links between curriculum, society, and culture, defining curriculum as a selection of ideas and concepts from the culture of a society and recognizing the importance that it be representative of social values.

The link between societal values and curriculum also extends to science curricula. Stuckey et al. (2013) note a need for science curricula to be personally relevant to the learner and generally relevant to society. Hodson (2003) also writes of a need for science curriculum oriented towards sociopolitical action. Duit and

Treagust (2003) make similar claims, linking potential changes in the outlooks and intentions of science learners with changes in their science knowledge.

While curriculum is affected by the social environment in which it is constructed, there are arguments towards limiting the influence of modern culture and society on it. These arguments are typically built around the idea that curricula should be based primarily on content knowledge, allowing learners to develop their own interpretation of its value. Muller (2012) argues that a curriculum strong in knowledge is needed for the continued development of social knowledge and policy. Wrigley (2018) argues that knowledge can play a significant role in improving the potential opportunities of disadvantaged youth. Deng (2022) argues that a knowledge-rich curriculum represents the key to developing human understanding, capability, and disposition in a society. While there is general agreement that the curriculum is influenced by social factors including culture, the degree to which this benefits education is continuing to be explored.

The current study views curriculum as the knowledge and skills deemed appropriate for students entering society based on the current societal values. These values are often dictated by those with both political and cultural power and frequently represent their interests. Defining curriculum this way helps to outline a view of curriculum development as both a process of determining what teaching is important to students during compulsory education and what knowledge is and should be valuable to those students.

As the curriculum can be viewed as both an educational document resulting from processes of policymaking and a means of socialization, it is important to study its development and the ways in which it is altered and revised. It is unlikely the processes that help to determine the appropriateness of newly emerging knowledge into curriculum are not affected by the political climate or social mores of the times. By exploring both the processes of curriculum development and those with influence on the process the current study hopes to shed some light on how these decisions are made and how they may affect future processes of education. This is exceedingly important as the development of new knowledge rapidly continues.

### 2.3 Curriculum Development as Education Policymaking

Policymaking in education in the United Kingdom can be a nebulous process. The ways in which educational policy is created can depend on the level of policy, national or local, the individuals the policy is intended to impact, primary or secondary students, and the resources available for implementation. These aspects of policymaking, combined with the large number of individuals typically involved in policy creation, creates a process that is at times difficult to define. Despite these problems, there is a basic method for national policy development. For the purposes of this study, policy will be defined as an attempt to consider objectives and the means to achieve them, and is also something that will occur at varying organizational levels such as the national level with the National Curriculum or local levels with staffing decisions (Baldock et al., 2013). This definition is very much in line with the typical goals of curriculum development as it outlines objectives for learning in classrooms and is a multilevel endeavor with implications both nationally and locally.

### 2.3.1 How is Educational Policy Created in England?

The process of national policy creation, while vague at times, has been documented by many researchers (Baldock et al., 2013; Bates et al., 2011; Bell & Stevenson, 2006; Forrester & Garratt, 2016; Trowler, 2003). It encompasses many stakeholders such as students, parents, and educators as well as other groups with different interests and levels of influence. In England, the process begins when the Cabinet identifies issues in education that need to be addressed (Forrester & Garratt, 2016). Possible solutions and resources for these issues are considered and incorporated into a document called a Green Paper (@UKParliament, 2015a). The aim of a Green Paper is to allow individuals both inside and outside government to debate the issue and resources while giving the department feedback on its potential solutions. The consideration of a Green Paper can be called Consultation. It is during this part of the national policymaking process that individuals outside the government are given an opportunity to discuss and consider the potential solutions outlined in the Green Paper. Persons considered a part of the educational profession such as teachers, educational researchers, local authorities, and schools are consulted as to the viability of the potential solutions outlined in the Green Paper. They also consider how the potential solutions will affect those involved. At this point other entities such as pressure groups, think tanks, and influential academic experts are also given an opportunity to weigh in on the debate.

After consultation and amendments, a Green Paper is re-presented as a White Paper. White Papers are government documents that set out details of a future public policy (@UKParliament, 2015b). At this point some policies require the approval of Parliament and can become laws, or Acts of Parliament, while others may move directly to the next phase of the process, Implementation, where policies will be dispersed to local schools and authorities. Figure 2.1 outlines the general process.

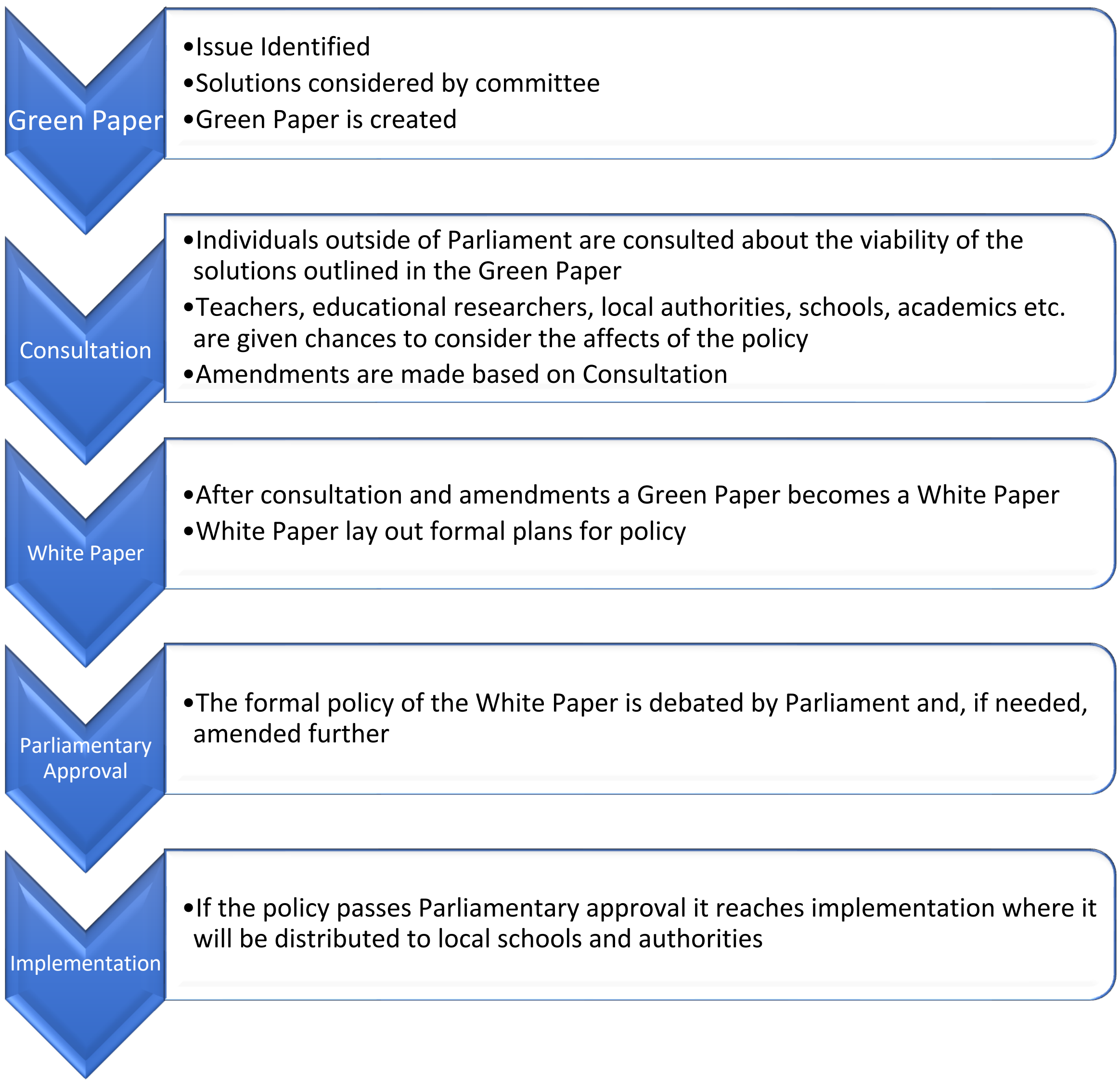


***Figure 2.1 National Educational Policy Making in the U.K.***

This model of policy making follows what Bates et al. (2011) refer to as the Rational Model of Policymaking. This model includes recognizing an issue, identifying solutions, weighing up the "best" way forward, implementing the policy, and evaluating its impact once put into practice. Although this model does represent a basic process of educational policy creation, things are not always as straightforward as presented here. Factors which are constantly changing as well as the roles of individuals involved make outlining a specific process problematic. Generally, the previously outlined phases do occur. The changes proposed by the Conservative/Liberal Democrat Coalition government were laid out in *The Importance of Teaching* seemingly followed this outline (DfE, 2010).

### 2.3.2 Educational Research and Policymaking

Another aspect to policymaking is the use of research. Policymaking in education and educational research can often have a remarkably symbiotic relationship. Oftentimes, research is the foundation for policymaking decisions at numerous levels of the educational process. I have defined policy as an attempt to consider objectives and the means to achieve them, it is also something that will occur at varying organizational levels. Policymaking can refer to attempts to influence education at the national level, such as Assessment for Learning in the United Kingdom or No Child Left Behind in the United States, at the local government level, or the school level with a head teacher or a department head instituting policy to promote a specific type of intervention. As a result, the term "policymaker" refers to any individual who holds the power to directly establish policy meant to affect teacher practice through consensus.

Policymakers at differing levels may use educational research in varying ways according to the needs and philosophies of the user. Nutley (2000) describes four ways in which educational research is used in policy making (Table 2.1). Each model outlines not only the process that policymakers may employ in developing education policy but also the means by which they make arguments about their goals and desired outcomes. In some approaches, educational research provides a foundation for the development of policy and in others it merely provides some semblance for an argument in the development of policy. The employment of educational research can have varying effects on the development of curriculum. Educational research can provide the impetus for change in curriculum or merely the argument a policymaker needs to implement what can be considered personal preferences in curriculum style. In some regards, this often makes educational research the basis for change or the explanation for why change is needed. It is important to point out the influence of sources outside of research can play a role in the use of educational research in policymaking. The ways that policymakers employ education research can have a great effect on the policy created and it is likely that it is incorporated in numerous ways based on desired outcomes and how it may be perceived by the public. Policymakers often contemplate the individuals whom the policy is intended to most directly affect when considering how educational research will impact policy.

***Table 2.1. Nutley's (2000) Four Ways in Which Educational Research is used in Policy Making***

| | |
|---|---|
| ***Political*** | Research is used to defend a political position |
| ***Engineering*** | Research provides hard data on which decisions are made |
| ***Enlightenment*** | Research does not directly inform policy, but its concepts inform the thinking of policymakers |
| ***Interactive*** | Research comprises only a part of the evidence in which policy is made |

The involvement of policymakers in educational research is a constantly evolving process. An example of this evolution can be observed when in the late 1990s the Labour Government introduced a number of reforms that would impact the way the policymakers would use educational research. These reforms were partially based on reviews and criticisms of educational research that included claims it often lacked rigor, failed to produce cumulative research findings, contained ideological biases, was sometimes considered irrelevant to schools, and lacked the involvement of teachers (Hargreaves & Teacher Training Agency., 1996; Hillage & Great Britain. Department for Education and Employment., 1998; Tooley et al., 1998). These reforms would put more emphasis on "Evidence-based" findings and practices that could impact the educational system. This approach in reform would have numerous consequences for researchers and teachers. For researchers, the impact would come in the form of changes to the types of research emphasized by the government. For teachers, the impact was that more emphasis was placed on student assessment. The rationale was that testing would provide a better means of measuring the success of teaching and educational policymaking in a manner easier to communicate with the public. In time, measuring school "success" this way would have some effects on the funding provided to educational researchers and institutions. Despite these changes, educational research is still an important contributor to educational policy creation and the process by which research is created and disseminated is show in Figure 2.2:

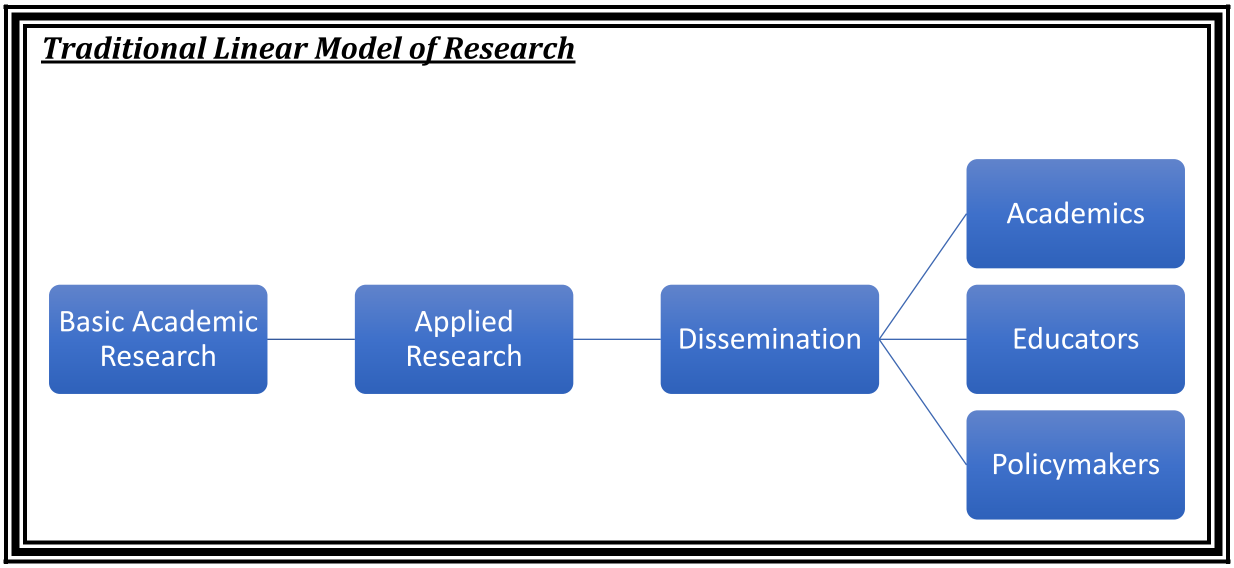


***Figure 2.2 The Traditional Model of Educational Research***

The use of educational research in policymaking can play a role in the development of curriculum. Individuals responsible for the contributing to the development of curriculum do not come to the process as blank slates. They bring with them a set of understandings and educational research can play role in how the curriculum is outlined and developed.

### 2.4 Curriculum Development as a Process of Human Agency

While the previously described model may represent a bird's eye view of curriculum development as a theoretical policymaking process, it does not capture the nuances of what happens in reality. A curriculum is the result of human agency and interaction and, as such, is a reflection of a set of beliefs about what students are meant to learn and the value of the knowledge within it (Prideaux, 2003). Curricula are often shaped by the societal values and beliefs about skills and knowledge that are deemed important. As outlined earlier, curriculum can be seen as the distillation of societal beliefs and culture through schools and capturing the interactions of those individuals involved may help to better outline how new knowledge is considered during processes of revision.

When considering the multiple points and interactions involved, it becomes difficult to consider curriculum development as a process with clearly delineated stages and a final product. It is more a continuous process of construction and modification with the potential to significantly impact many aspects of society (Lau, 2001). Bens et al*.* (2021) note four major factors that can limit the curriculum development processes. Table 2.2 outlines these factors:

**Table 2.2 Factors that Enable and Limit Curriculum Development**

| ***Factor*** | ***Description*** |
|---|---|
| **Contexts and Culture** | What characterizes participation? |
| **Structures and Resources** | How is the work organized? |
| **Attention and Focus** | What gets discussed? |
| **Educational Developers Contributions** | How do developers participate in the process? |

According to Bens et al., the factors that most greatly affect the processes of curriculum development can be tied to how participation in the process is defined and perceived in addition to how the work is organized and carried out. These factors can be separated into two elements. Firstly, there is the make-up of the curriculum working group and their perceptions of the process and their role within it (Contexts and Culture/Educational Developer Contributions). These factors can be described as how those participating in the development process see their role in the process and the influence they hold over the outcomes. In the literature, curriculum development is often a process described ideally as collaborative and reflective of the viewpoints of many stakeholders (Adagale, 2015; Oliver & Hyun, 2011). When there is high trust, common vision, and an openness to change amongst those participating, the curriculum development process can be perceived by stakeholders as transparent and innovative. When these elements are missing, the pedagogic communication and discourse that result from curriculum development can often be seen as lacking input by those most affected (Voogt et al., 2016). I will refer to the aforementioned as Participant factors.

Secondly, there are the processes the curriculum development working group employs to make determinations about what specific elements belong in the curriculum, how it should appear, and the precise language used to convey meaning and guidance (Structures and Resources, Attention and Focus). If the Participant factors mentioned above center on the "who and why" of curriculum development, then these factors focus on the "what and how" of the process. The focus here is placed on how the working group makes decisions about what knowledge specifically belongs in the curriculum, what students are meant to learn about that knowledge, and what language will be used to describe student expectations and direct teachers towards these goals. There is discussion amongst curriculum researchers about where emphasis should lie within these processes, with some researchers espousing the view that curricula should be based on knowledge that arises from historical, social, cultural, and political forces (Aikenhead, 2006; Smith, 2011). Others prefer a process that emphasizes development based on specific content knowledge with little deference paid to social or historical context (Beck, 2013; Young, 2013). These factors will be referred to as Process factors. In some regards, the arguments surrounding the Process factors during curriculum development and revision mirror the debate of the role of culture in the curriculum.

Both Participant and Process factors play important roles in the development of curriculum as both can be influential in how curriculum development committees are established and the ways they work in developing curriculum documents. Explorations of curriculum development processes in Ghana found the development of curriculum highly political but empowering and emancipating for contributing members as they became decision makers made more aware of the influence of culture on the process (Gervedink Nijhuis et al., 2013; Mfum-Mensah, 2009). Priestly et al. found that a clear vision during national processes of curriculum development can lead to innovation at the school level (Priestley & Humes, 2010; Priestley et al., 2014). On the other hand, Westbury found that processes including practices such as compartmentalization, segmentation, and licensing helped to develop curricula as guiding instruments largely based on symbolism and ideology (Westbury et al., 2016).

## 2.5 Research Questions

In this chapter I have endeavored to outline some of the connections between society, culture, curriculum, and what is taught in schools. I have outlined how a curriculum can be seen as being reflective of knowledge deemed valuable to society and how that viewpoint goes on to affect the development of teaching materials such as textbooks and classroom lessons. While these connections are reflected in the literature, studies outlining the processes by which these connections are made remain scarce. While researchers continue to study the links between culture, curriculum, and teaching in schools, there is a level of neglect in determining how decision-making at various levels ultimately creates these links. This gap in the literature leaves numerous unanswered questions about the nature of the processes that determine what knowledge is valuable enough to be included within curriculum and how that knowledge is modified for inclusion in classroom teaching. This study attempts to give some insight into these concepts by exploring two primary research questions:

1. *How did genomics knowledge come to be introduced into the National Curriculum for England?*
2. *What does this reveal about the processes that select and transform newly developed knowledge into curriculum and lessons in secondary science courses?*

Using the introduction of genomics knowledge into the National Curriculum for England's Science PoS (DfE, 2014) as the basis, this study seeks to better understand how contemporary science research relates to what is taught in schools. This exploration can help to better outline the processes that select and transform certain aspects of contemporary science research into curriculum meant to be taught in secondary science courses in English schools.

These research questions were derived from a process beginning with examining how newly emerging ideas in science become lessons taught in science courses. From here different areas such in modern scientific and technological research were explored through many preliminary literature searches, along with conversations with my supervisors. Time was also dedicated to exploring what influences teacher decision making in lesson planning in terms of scientific content. As what is taught in secondary schools is often linked to what appears in the curriculum, a decision was made to focus on the process of curriculum development and the introduction of new research science concepts.

This broad exploration led to the specific example of genomics as a scientific concept as it had been added to the 2014 National Curriculum's Science PoS (DfE, 2014) during revision processes beginning in 2011 and eventually adopted for teaching in 2016. This presented an excellent opportunity to obtain data from multiple participant sources familiar with the event and documents describing it. Continued examination eventually led to an exploration of the processes that determine how new knowledge is introduced into the National Curriculum and the individuals and organizations that hold influence and sway.

A case study approach was employed to explore the processes that saw the consideration of the addition of genomics knowledge into the National Curriculum's

Science PoS (DfE, 2014). The case focused both on the years leading up to and during the revision of the National Curriculum initiated by the Conservative Government in coalition with the Liberal Democrats in 2011. Although the case is focused on this period, there are also many historical contextual factors that played a role such as the completion of the Human Genome Project.

## 2.6 Summary

This chapter outlined how curriculum development can be seen as a process of determining what knowledge is important for students leaving compulsory school and joining society. This process can be influenced by many factors such as perceived societal value, politics, economics, and educational research. While curriculum development itself can be seen as a theoretical process impacting culture and society, it is also a practical process of policymaking carried out by individuals with agency and subject to the same factors of impact of any process of policymaking.

The implications here are that the curriculum involves a process of policymaking under the control of those with political and cultural power. This power structure creates an environment where curriculum, and the society it is created for, often impact each other and the two are closely intertwined. Studying how genomics came to be introduced into the National Curriculum's Science PoS (DfE, 2014) may help to better understand how each impacts the other.

As this study looks to explore the eventual inclusion of genomics into the National Curriculum's Science PoS (DfE, 2014), the next chapter will review the scientific concept of genetics and its study in secondary schools in England. This will help to set a foundational understanding of genetics as both a scientific discipline and the basis for its current teaching in secondary schools.

## Chapter 3: Genetics and Secondary Schools

The current study seeks to explore the processes that saw genomics knowledge included in the National Curriculum for England's Science PoS (DfE, 2014). It is important to outline the basics of genetics study as a science. In this chapter, I will outline the history of genetics as a research science before delving into the philosophy behind its teaching. This will help to inform our understanding of what has been traditionally taught in schools and why the addition of genomics into the National Curriculum's Science PoS (DfE, 2014). represented is worthy of note and exploration.

Genetics is the study of how organisms pass traits from parent to offspring. Genomics can be defined as the study of the entire genomic makeup of an organism as opposed to individual genes (Martin & Hine, 2015). Of great importance to the discussion are the differences between genetics and genomics, the most prominent being that although genomics itself is part of the overall scientific field of genetics, its greater emphasis on the study of an organism's entire genome as well as the interactions of multiple genes and the non-coding portions of genetic material sets it apart from classical genetics which tends to emphasize single gene interactions and the portions of genetic material that code for protein synthesis. Both are focused on how genetic makeup (genotype) influences the expression of physical characteristics (phenotype).

This chapter will also examine the changes to the text of the National Curriculum concerning genomics knowledge and the expectations these changes impart regarding its teaching. The addition of genomics knowledge into the 2014

National Curriculum's Science PoS (DfE, 2014) represents a shift from the previous curriculum and comparing and contrasting the National Curricula published in both 2007 and 2014 helps to outline key differences. I will also examine which aspects of genetics intended for teaching in schools were changed and which aspects of genomics were included in the most recent curriculum revision.

## 3.1 What is Genetics?

The study of genetics is rooted in the study of how physical traits are passed to offspring from parents. Since its inception as a biological science, the teaching of genetics has played a key role in the teaching of many biological concepts such as evolution, population studies, and environmental biology. In this section, I will outline the history of genetics as a research science to establish its foundational basis for modern science teaching. This history will be split into two eras: the Classical Era encompassing the 1850s through the 1960s and the Modern Era encompassing the 1970s through to the current time period.

### 3.1.1 The Classical Era 1850s-1960s

The term genetics refers to the study of patterns of heredity, or how traits in an organism are passed from one generation to the next through chromosomes, structures made of dexoyribose nucleic acid (DNA) that carry genes (Martin & Hine, 2015). Typically part of the biology school curriculum, the teaching of genetics often encompasses exploring the ways in which organisms pass on traits – physical characteristics – from parent to offspring during reproduction and how this effects not only individuals within a species, but a species as a whole. This aspect of biological science plays an important role in the teaching of life science as it contains many concepts key to understanding the continued existence and propagation of life such as reproduction, evolution, adaptation, and variation (Tsui & Treagust, 2010). Genetics also plays a key role in the teaching of biological compounds such as nucleic acids and proteins as it provides a basis for understanding how these structures are created and function at the cellular level (Thörne & Gericke, 2014).

Much of what is taught in secondary genetics courses is based on the single gene model of genetics which draws on conclusions inferred by Gregor Mendel from his experiments with pea plants in the late nineteenth century (Kim & Irving, 2010). Mendel's work encompassed carrying out a number of experiments involving crossing the varying traits of pea plants such as seed shape, color, and plant height (Dunn, 1991). His first conclusion posited that hereditary factors determine physical characteristics in organisms and that these factors occur in duplicate in parents, although offspring receive one of these factors from each parent for each trait during reproduction (Bateson & Mendel, 2013). His second conclusion posited that these factors sort independently of each other during the formation of sex cells, or gametes, in parents but recombine during reproduction of offspring (Bateson & Mendel, 2013). Mendel did not know what these factors or "units of heredity" were, but he did understand their existence and role in passing physical characteristics from parent to offspring.

Mendel's work would eventually form the basis of classical genetics with his two conclusions, later named Mendel's Law of Segregation and Mendel's Law of

Independent Assortment. His work would largely go unnoticed during his lifetime. It was only later in the early twentieth century that his work would be revisited, confirming his findings (Chong et al., 2015). The hereditary units that Mendel was referring to would eventually be called genes and the study of them called genetics. Throughout the twentieth century, his work would form the basis for the study of how genetic information is passed from parent to offspring.

This time period, from the 1850s to the 1960s, which I have termed the Classical Era, was mostly concerned with finding out the specifics of the "rules" of heredity put forth by Mendel and the roles structures within the cell play in it. The focus would be determining the relationships between structures such as DNA, ribonucleic acid (RNA), proteins, and chromosomes and their influence on heredity (Shapiro, 2009). Many advancements in this period would lead to increasing scientists' understanding of what would come to be called the Central Dogma, or the flow of hereditary information from DNA to RNA to proteins and unraveling the mysteries of their interactions and connections (Crick, 1970).

Although Mendel himself saw the units of heredity as more concept than reality, scientists of the Classical Era would concentrate their efforts on determining exactly why his conclusions on the nature of heredity were correct. Innovations in microscopy and molecular biology allowed scientists to make many discoveries about the nature of the cell and the structures within it (Wilson, 1997).

By the early twentieth century, genetics would emerge as a discipline that incorporated other biological disciplines such as cytology and embryology. Many important aspects of the discipline were uncovered in this era, such the discovery of the gene as the unit of heredity, DNA's importance as the cell's genetic material, and the role of proteins in the development of physical characteristics (Gayon, 2016; Nakamura, 2009; Nielsen et al., 2009). The discoveries of this era would culminate with Watson, Crick and Franklin's discovery of the double helix structure of DNA, which would lay the groundwork for understanding the role of DNA in regard to heredity (Watson & Crick, 1953).

By the late 1960s, the knowledge amassed during the Classical Era would create the basis for the next era of genetics. Much of the relationship of DNA, RNA, proteins and their respective roles in passing genetic information from parent to offspring had been illuminated, establishing the aforementioned 'central dogma' (Gayon, 2016). Despite these advances in knowledge, questions still remained about the nature of heredity. The single gene model of genetics could not fully account for many mysteries such as the numerous factors affecting gene expression or how genetic information travels from the nucleus, the structure found in eukaryotic cells that contains the genetic material, to the ribosome, the site of protein synthesis (Martin & Hine, 2015). More study was needed leading to a new era in genetics. While the Classical Era emphasized the nature of single genes and the role of DNA, RNA, and proteins in single gene heredity, this next era would emphasize how understanding the nature of the entire set of genes in an organism and what knowledge of that set, or genome as it is now called, can tell us about the organism (Leng et al., 2022).

### 3.1.2 From Genetics to Genomics: The Modern Era 1970s-Today

If the Classical Era can be defined by advancements in understanding the relationships of DNA, RNA, proteins and single gene genetics at the cellular level, then the Modern Era can be characterized by its emphasis on studying the interactions of multiple genes in organisms (Lowe et al., 2022). This new emphasis in genetics would slowly arise as breakthroughs in technology increased the ability of scientists to amplify or replicate a section of the genome resulting in the production of genetic material containing many copies of a specific sequence of DNA (Martin & Hine, 2015). These advancements allowed geneticists opportunities previously unconsidered and allowed for more advanced research. In this era, the understanding of the interactions of multiple genes would become a new emphasis, as new branches of science such as molecular genetics would emerge.

During this era, numerous advancements would be made, such as the cloning of the first animal genes, the development of revolutionary sequencing techniques such as the Sanger method, and the creation of methods that allowed for the creation of large amounts of DNA from small samples such as polymerase chain reaction or PCR (Rapley, 1998; Rubin & Lewis, 2000; Sanger & Coulson, 1975). These breakthroughs, as well as many others, would lead to and influence the emergence of the field of genetic engineering, or the altering of characteristics of an organism by altering its genome (Martin & Hine, 2015; Wright, 1993). Many branches of science would come to be heavily influenced by this field of genetics, as it would lay the groundwork for advancement in medical science such as potential medical cures for disease, agricultural science such as the creation of genetically modified foods, and many others (Bartlett & Stirling, 2003; Zhu et al., 2020). Genetics would evolve from a laboratory science geared towards explaining the phenomenon of heredity to a practical science that could affect nearly all people in previously unseen ways. The breakthroughs would also lead scientists to studying the entire set of genes an organism carries. This new field of genetics would be called genomics and its emphasis would be exploring how the interactions of multiple genes could possibly explain some of the gaps in knowledge left by the single gene model of genetics (García-Sancho et al., 2022).

As stated previously, the study of genomics encompasses studying an organism's genome, all of the genes it carries. Its development as a discipline within genetics began in the 1980s with some of the advancements mentioned earlier which allowed for the collection and analysis of large amounts of data on the nucleotide and protein sequences of various organisms (Martin & Hine, 2015). Genomics also offered great potential for use in modern medicine if certain levels of understanding about the human genome could be reached. Understanding concepts such as the identification of mutations linked to different types of cancer or the genetic influences on some types of viral infections could be very beneficial to the scientific community as potential treatments to these diseases could be developed. It was in this vein that the Human Genome Project began.

Begun in 1990, the Human Genome Project encompassed an international effort among research geneticists to sequence all of the estimated 30,000 to 100,000 genes of the human genome within 15 years of beginning (Sawicki et al., 1993). The effort was an immense one requiring unprecedented levels of international collaboration by biological and medical scientists (Collins et al., 2003). The project culminated in 2003 and its implications for science and medicine are still being considered today. Its potential impact on society, and especially education, is the basis for this study. The study of genomics has also led to further explorations in genetics such as epigenetics and population genetics.

Modern genetics now encompasses the study of heredity across numerous organisms and populations. The study of genetics has been very important in helping scientists to study and understand many important details about the existence of life, such as the importance of DNA and the ability of a species to change over time to adapt to environmental factors (Allendorf et al., 2010; Feero & Guttmacher, 2014; Strachan et al., 2014). The study of genetics has also made contributions to the study of medical science such as genetic screening and is continuously being evaluated for greater widespread use in areas such as personalized medicine (Cooper & Psaty, 2003; Hamburg & Collins 2010).

As seen above, the study of inheritance has gone through significant changes. Both medical and technological advancements have seen the landscape in genetics research shift over time from an emphasis on the single gene classical model towards the multiple gene, genomics-based model. Yet there are questions about whether this shift in scientific research has been captured in the curricula that modern students experience or whether there is perceived benefit for students to study emerging scientific concepts in inheritance at all. This makes studying the introduction of genomics into the National Curriculum a good point for exploring how newly emerging scientific knowledge becomes part of the curriculum and what is taught. The revision to the National Curriculum's Science PoS (2014) yielded more mention to genomics-based concepts at the secondary level giving the current study an opportunity to explore the processes and influences that contributed to this change. While this section has focused on the study of inheritance as science, the next will focus on its study in secondary classrooms in the England.

## 3.2 Genetics in Secondary Schools

Genetics has long been a part of science teaching in secondary schools. As the last section outlined genetics' emergence as a research science, this section will look at how the subject has been approached in secondary schools. As the goal of the study is to gain a better understanding of how newly emerging scientific research finds its way into classrooms, exploring the traditional ways genetics has been taught in secondary schools will help to establish the significance of changes between the 2007 and 2016 National Curricula and their approaches to the teaching of inheritance.

### 3.2.1 Classical Genetics in Secondary Schools

The Classical or Mendelian model has been very influential in the teaching of inheritance in secondary schools. Much of the teaching of inheritance has traditionally been based on this single gene model of genetics. Emphasis is often placed on students learning about the role of nucleic acids, genes, and proteins in the passing of physical traits from parent to offspring as well as the cellular processes involved, such as mitosis, meiosis, and protein synthesis (Banet & Ayuso, 2000; Kılıç et al., 2016; Kim & Irving, 2010). This approach has typically focused on teaching students a combination of the cellular processes involved in cell division, the development of sex cells (gametes), the passing of traits from parent to offspring, and the probabilities of traits being passed and how they are expressed in organisms.

The emphasizing of these areas of genetics in teaching has not been without scrutiny. Recently, questions surrounding the suitability of the teaching of the Classical Model of genetics have become more prevalent. Knippels (2002) identified five major difficulties when teaching genetics: a) the domain-specific vocabulary and terminology (e.g., accurately defining terms such as gene and mutation), b) the mathematical content of Mendelian genetics tasks (e.g., needing to calculate the probability offspring will exhibit a trait), c) the cytological processes (e.g., describing how protein synthesis relates to gene expression), d) the abstract nature of the subject in the biology curriculum (e.g., describing the relationship between DNA, genes, and physical traits), and e) the complex nature of genetics as a macro-micro problem (understanding the difference between gene expression in populations vs individuals). These difficulties can lead to secondary science students misunderstanding several important genetics concepts.

These issues often act as barriers when it comes to secondary students learning genetics. Machova and Ehler (2021) noted numerous misconceptions about the rules of inheritance and the functions of DNA when studying secondary students in the Czech Republic. Lewis et al. (2000) had similar findings when studying secondary students in England. Both studies revealed a disconnect between how students perceived the rules of inheritance outlined by the Classical Model and their understanding of cell processes. Aivelo and Uitto (2021) found these misconceptions can lead students towards adopting a sense of genetic determinism, the feeling that an organism's health outcomes are disproportionately tied to its genetic profile.

There are arguments that the problem lies less with the content and more with the way it is delivered. Longden (1982) notes problems with student learning in genetics could be connected to the representation of the aforementioned cellular processes such as meiosis and the timing with which concepts are presented. The sequence in which genetics concepts are presented to students can have an effect on how students understand and interpret their meaning. Tsui and Treagust (2010) link the issues with the preconceived notions that learners bring to the lessons which often go unaddressed as teachers try to adhere to the Classical Model, such as the expression of parental traits in offspring. Students often carry a misconception that offspring carry the blend of a trait (tall father and short mother yield offspring with height in between) as opposed to understanding that offspring often exhibit the trait of the father *or* the mother.

Whether the problem lies within the Classical Model or approaches in presenting it to secondary students, questions surrounding the difficulty of teaching the Classical Model of genetics in secondary schools continue to be raised (Dawson & Venville, 2010; Kılıç et al., 2016; Lewis & Kattmann, 2004; Machová & Ehler, 2021). They often center on the nature of newly emerging genetics knowledge in the current curriculum. These questions focus on the role of genetics learning in response to genetics teaching as opposed to the genetics learning in response to preparing students to interact with it outside of the classroom. Much of the current literature also focuses on how students perceive the Classical Model of genetics as opposed to the more modern elements of current genetics research as described previously.

### 3.2.2 Modern Genetics in Secondary Schools

The current debate in genetics teaching and learning is typically centered on whether the Classical Model truly prepares students to interact with genetic information outside of the classroom as more modern genetics becomes a part of the daily lives of students. As discussed above, the expansion of the role of genetics in the everyday lives of students has been fueled by breakthroughs in genetics technology and research. This has brought about numerous advancements in areas with strong ties to human activity such as medical science, ecology, and economics.

Despite the growing influence of modern genetics, the Classical Model of genetics has remained prevalent in science teaching (Smith & Wood, 2016). The growing influence of modern genetics in the everyday lives of students combined with a push towards greater scientific literacy and its goals of creating citizens that understand how scientific research is conducted and the knowledge it produces has led to new questions about the role of modern genetics in science teaching (Stern & Kampourakis, 2017).

Questions surrounding the teaching of the Classical Model of genetics and the role of more modern genetics are not new. They are often centered on two elements. Firstly, there are the previously outlined limitations of teaching the Classical Model (3.2.1). Many argue that where the classical, single gene model of genetics can be seen as too focused on simple mathematics and abstract concepts within the subject while modern genetics is more concerned with real world application and human influence (Boerwinkel et al., 2017; Dawson & Venville, 2010; Lewis & Kattmann, 2004). Secondly, there is the shift towards developing students' conception of "genetics literacy", or their ability to discuss the conceptual, sociocultural, and epistemic values of genetics knowledge (Boerwinkel et al., 2017). Both arguments posit that introducing students to more modern genetics knowledge helps students to form greater connections to the subject and increases understanding.

Ben-Nun and Yarden (2009) note introducing students to modern techniques in bacterial DNA manipulation resulted in increased understanding of the role of DNA in determining an organism's traits in high school students. Todd et al. (2017) revealed that employing learning progressions that included modern genetics ideas, such as genomics studies and the exploration of epigenetics, resulted in greater achievement in genetics assessments. There is even evidence that modern genetics can be linked to increasing teacher understanding of the subject with Taskin and Ozgur (2019) noting that professional development containing elements such as genome-wide association studies and bioinformatics provides teachers with anchoring elements that help improve student learning.

Even as questions of introducing modern genetics into secondary science courses are explored, questions surrounding the processes that transform this knowledge persists. There have been studies on the relevance of studying genetics at the secondary level and what content is suitable, but little regard has been paid to the processes that determine what is taught or how it is transformed into new curriculum or classroom lessons.

As evidenced above, as research into inheritance and genetics continues to shift focus towards more multiple gene, genomics-based models, teaching in secondary classrooms continues to emphasize the single gene, Classical Model. This is important to the context of the current study as it helps to establish the significance of the changes between the 2007 and 2014 National Curriculum's Science PoSs. As established previously, curricula often form the basis for the development of teaching materials and what is taught in classrooms. It can also be interpreted as the knowledge determined important for students upon leaving compulsory schooling and the inclusion of genomics represents a shift towards more modern aspects of genetics knowledge. This can be seen in both curricula and science education literature (Gericke & Smith, 2014; Marques et al., 2014; McGuire et al., 2020). As educational literature considers the inclusion of genomics as important for students to develop their genetics literacy, I will now consider how changes in the National Curriculum's Science PoS (DfE, 2014) reflect its inclusion and what that means to the current study.

## 3.3 Genetics in the National Curriculum for England

Genetics is taught in secondary schools in England as part of the biology curriculum (DfE, 2013a, 2014). Commonly referred to as *inheritance* in curriculum documents, it is broken down and introduced as smaller subjects that help students to understand other biological concepts such as reproduction, variation, and evolution. Inheritance has been a part of the National Curriculum since its inception in 1989, but has undergone some changes since then (Pumfrey, 1991). The National Curriculum periodically undergoes processes of revision with the last occurring between 2011 and 2014. It is important to highlight the changes that came about as a result of this revision as the study seeks to better understand the processes which resulted in these changes.

As there are specific differences in terms of genetics teaching between the 2007 and 2016 curricula, a comparison between the genetics portions of these two curricula can help to highlight the changes that occurred. As the current study focuses on secondary science courses, I will focus on reviewing Key Stages 3 and 4. This is appropriate as many high-level concepts in inheritance are taught in these age bands.

### 3.3.1 Genetics in the 2007 National Curriculum

Prior to the 2010-2013 Revision process, the National Curriculum for England presented the study of inheritance in secondary schools in Key Stage 3 and Key Stage 4. Listed under the sub-heading *Organisms, behavior and health*, Key Stage 3 presented the following regarding the teaching of genetics:

- *All living things show variation, can be classified, and are interdependent, interacting with each other and their environment*
- *Behaviour is the influenced by internal and external factors and can be investigated and measured*

(QCA, 2007a)

Components of genetics were also found in Key Stage 4. Listed under the subheading *Organisms and health*, it goes on to add:

- *Human health is affected by a range of environmental and inherited factors, by the use and misuse of drugs, and by medical treatments*

(QCA, 2007b)

The 2007 National Curriculum represented significant changes from the version that preceded it. Created by the Qualifications and Curriculum Authority (QCA), much of the document was "slimmed down" and less detailed than the previous iteration and was meant to provide teachers with more autonomy in preparing their students (Millar, 2011). The curriculum to follow, developed by a government with a different philosophy, would stand in strict contrast.

### 3.3.2 Genetics in the Current National Curriculum

The 2010-2013 Revision process would result in the addition of more detail added to better explain content and learning goals. While the previous curriculum had been authored by QCA under a Labour-led Government, the 2010-2013 Revision would be initiated by the Conservatives in coalition with the Liberal Democrats and include some fundamental changes in efforts to return what they considered to be a more “rigorous” curriculum (Conservative, 2010). This would include expanding some elements of science content in addition to specifying what secondary students were meant to learn.

Key Stage 3 is the first time in the National Curriculum’s Science PoS the word “genetics” is actually used. It is here that many key terms such as heredity, gene, DNA, and chromosome are introduced and the understanding of genetics as a phenomenon that encompasses all living things is emphasized. At this point in the curriculum, the students, typically aged 11-14, are taught the following:

- *Heredity as the process by which genetic information is transmitted from one generation to the next*
- *A simple model of chromosomes, genes and DNA in heredity, including the part played by Watson, Crick, Wilkins and Franklin in the development of the DNA model*
- *Differences between species*
- *The variation between individuals within a species being continuous or discontinuous,*
- *To include measurement and graphical representation of variation*
- *The variation between species and between individuals of the same species means some organisms compete more successfully, which can drive natural selection*

- *Changes in the environment may leave individuals within a species, and some entire species, less well adapted to compete successfully and reproduce, which in turn may lead to extinction*
- *The importance of maintaining biodiversity and the use of gene banks to preserve hereditary material*

(DfE, 2013a)

Here students are becoming familiar with much of the basis for genetics as a science. The importance of DNA and its role as genetic material is covered and students are introduced to some real world application of the study of genetics such as gene banks. This portion of the curriculum was last updated in September 2013 as a result of the 2010-2013 Revision. The contrast in specificity and preciseness is apparent upon initial inspection.

Key Stage 4 represents the first mention of the term "genome" in the National Curriculum's Science PoS (DfE, 2014). Pupils, typically aged 14 to 16 and having previously been introduced to the basic concepts of genetics, are taught more real-world application as they are introduced to the basics of the genome and the importance of modern genetics. Here students are taught the following:

- *The genome as the entire genetic material of an organism*
- *How the genome, and its interaction with the environment, influence the development of the phenotype of an organism*
- *The potential impact of genomics on medicine*

- *Most phenotypic features being the result of multiple, rather than single, genes*
- *Single gene inheritance and single gene crosses with dominant and recessive phenotypes*
- *Sex determination in humans*
- *Genetic variation in populations of a species*
- *The process of natural selection leading to evolution*
- *The evidence for evolution*
- *Developments in biology affecting classification*
- *The importance of selective breeding of plants and animals in agriculture*
- *The uses of modern biotechnology including gene technology; some of the practical and ethical considerations of modern biotechnology*

(DfE, 2014)

They are also introduced to the ethical considerations of genetics research such as genetic engineering and cloning. It is of note that this portion of the science curriculum was last updated in December 2014 as opposed to September 2013, making it the most recently updated part of the curriculum. It is also of note that the curriculum, as it currently exists, could be said to represent a change in science education philosophy that may reflect the government of the time, moving from the ideas of scientific inquiry/science as a process of the previous Labour governments towards the emphasis on science content knowledge of the Conservative

Government (Conservative, 2010). There is also a question surrounding what the connection between what specifically appears in the National Curriculum and what is being taught in secondary classrooms (Gallagher et al., 2012; Klenowski & Wyatt-Smith, 2010). Although references toward genomics do appear in the National Curriculum's Science PoS (DfE, 2014), that does not make it a given that it is being taught by secondary teachers as assessment can play a very big role in what is emphasized in classrooms (Ramatlapana & Makonye, 2012).

### 3.4 Why Study Genomics and the National Curriculum?

As signified earlier, the introduction of genomics knowledge and language into the National Curriculum for England's Science PoS (DfE, 2014) came about during the 2010-2013 Revision Processes. The research questions of this study aim to explore the processes that resulted in its introduction into the National Curriculum. As evidenced in this chapter, there is a long history of studying inheritance and genetics in secondary science courses. This history is largely based on the Classical Era of genetics research. While significant breakthroughs in technology have seen changes in the study of inheritance moving from the single gene model to the multiple gene model, those changes have not been seen in the National Curriculum until recently. It can be inferred the current National Curriculum represents some potential change in either viewpoint, power, or values regarding what elements of inheritance are important to coming generations.

This makes studying the introduction of genomics knowledge into the National Curriculum's Science PoS (DfE, 2014) a prime case for exploring how newly developing scientific concepts and ideas become part of what is covered in secondary science courses. Examining the progression of genomics from only being alluded to in the 2007 National Curriculum to a relatively substantial portion of the current Key Stage 4 National Curriculum in Biology provides information on how this emerging knowledge ultimately became curriculum content and the factors that influence the knowledge transformation in the process. While the relatively recent 2010-2013 Revision allows for the collection of multiple data sources outlining some decision-making processes, it also represents an ideal case for exploring how this new knowledge is transformed from research science to secondary school science.

### 3.5 Summary

In this chapter I have outlined the study of inheritance and genetics in terms of both research science and secondary classroom study. Although some aspects of genetics knowledge have seen rapid growth in the recent decades, until recently the secondary science curriculum in England has been primarily based on the Mendelian, single gene model, although changes made during the 2010-2013 Revision to the National Curriculum resulted in the addition of some more modern concepts of the multiple gene model approach of genomics. While the science education literature itself reveals some arguments about the appropriateness of this Classical Model for contemporary students and whether more modern concepts in genetics would better prepare students for their futures, there is little attention paid to the processes that would select and transform these new aspects of emerging genomics knowledge into curriculum and classroom lessons.

While this chapter focused on inheritance and genetics as research science and curriculum content, the next chapter will focus on how changes to curriculum inevitably lead to changes in teaching resources and materials. As the goal of the study is to better understand how new ideas in science research become what is taught in schools through the exploration of how genomics came to be introduced into the National Curriculum's Science PoS (DfE, 2014)., it is important to highlight and examine how change in the curriculum leads to changes in resources. Ultimately these changes can result in the change of societal viewpoints overtime.

# Chapter 4: Genomics in Classrooms

In the previous chapters, I discussed links between the curriculum and the knowledge valued by society (Chapter 2). I also delved deeper into the how these links have affected the positioning of genetics in the National Curriculum including the eventual inclusion of genomics knowledge during the revision which began in 2011 (Chapter 3). In this chapter, I will investigate the effects of the inclusion of genomics knowledge into the National Curriculum for England's Science PoS (DfE, 2014). on science teaching resources. The literature does reveal some links between curriculum, standardized testing, teaching resources and materials, and what is taught in classrooms. Exploring these elements can help to consider how changes in the curriculum may lead to changes in what is taught in schools. First, I will examine some of these links and then take a look at a specific resource based on the changes to the National Curriculum for England's Science PoS (DfE, 2014).

## 4.1 The National Curriculum and School Teaching

While the curriculum can be seen as representing what is meant to be taught in schools, there are numerous factors that contribute to the specific lessons that teachers present to their students. Teachers' content and pedagogical knowledge, previous student learning, and colleague interactions are just a few of the factors that help determine how teachers decide what lessons to present to their students (Boesdorfer et al., 2019; Loewenberg Ball et al., 2008; Van Eekelen et al., 2006). Curricula, as a whole, often contribute to what is taught but it is by no means the sole factor.

While the curriculum is not the sole factor in determining what is taught, it is definitely important. Sanchez and Valcarcel (1999) found that content and objectives, as outlined in curriculum documents, represented a significant role in teacher planning and decision-making in teachers in Spain. Luft (2009) found that first year science teachers often depend on curriculum documents as a basis for designing and delivering lessons in the United States. Arias et al. (2016) found the use of curriculum documents helped to increase the likelihood of science teachers integrating new practices into their teaching.

In England, the National Curriculum is no different, although it can be argued the National Curriculum's influence often occurs through indirect means in the form of exam specifications and textbooks. Exam boards such as the Assessment and Qualifications Alliance (AQA) and Oxford, Cambridge, and RSA Examinations (OCR) are influenced by the National Curriculum's PoS in the creation of both exam specifications and textbooks for the General Certificate of Secondary Education (GCSE), national exams administered to students at age 16, and General Certificate of Education Advanced Level (A-Levels) courses which determine university admissions. Secondary teachers often use these materials to determine the content they will emphasize in their teaching.

Previous studies draw direct links between what appears in examination specifications and what is taught in classrooms. Whalley's (2020) examination of A-Level Geography specifications reported that teachers routinely choose topics of emphasis based on specifications and that these choices often affect student choice. A 2016 report commissioned by the National Union of Teachers and carried out by researchers at King's College London also found links between teaching and exam specifications. Examining data taken from secondary teachers across the United Kingdom, researchers found that 76% of teachers of English and mathematics strongly agreed that their classroom practice became more focused on examination and test preparation as result of the GCSE reforms that affected exam specifications (Neumann et al., 2016). Horrell et al. (2018) also make references to links between what appears in exam specifications and what is taught while studying the absence of religion and media in 2016 GCSE specifications. Carrying out analyses of several specification documents, they argue the absence of these concepts in exam specifications will likely send a signal to teachers that the subjects are not worth teaching.

Based on these and other findings, it can be said that teaching and exam specifications are inexorably linked. If the curriculum represents the knowledge valued by society, then inclusion in exam specifications can be said to represent an indication of what is important enough to be examined as part of national testing. In essence, the two work in tandem in selecting what knowledge is deemed appropriate for students entering society post compulsory education.

As our study uses the introduction of genomics into the National Curriculum's Science PoS (DfE, 2014) as a means of exploring how new discoveries in science become what is taught in science courses, it is important to consider how the National Curriculum affects the development of further resources utilized by teachers. As curriculum often forms the basis for the development of exam resources such as textbooks and these materials do affect decisions teachers make about their priorities in subject and time in classrooms, exploring how changes in curriculum lead to changes in resources based on the curriculum can give us some insight into what is being taught in secondary courses.

### 4.2 Current Exam Specifications in Genetics and Inheritance

It is clear that what appears in the curriculum forms the basis for what appears in teaching resources such as exam specifications. This, in turn, means what appears in exam specifications affects what is taught. As such, the inclusion of genomics knowledge into the National Curriculum's Science PoS (DfE, 2014) alone may not be enough to infer what is happening regarding its teaching in secondary science courses across England. In this section, I will explore the examination specifications for biology from AQA from two periods: 2012 GCSE Biology Specifications and the 2016 GCSE Biology Specifications to consider what elements of genomics were included. As exams play a key role in the decision-making of teachers, examining how specifications change due to curriculum change can highlight the connections between the changes to the National Curriculum, GCSE specifications influenced by those changes, and what is being taught in secondary courses (Arias et al., 2016; Whalley, 2020). The 2012 Specifications are for GCSE exams set from 2014 forward while the 2016 Specifications are for exams set from 2018 onwards. While exploring the biology portion of the National Curriculum in isolation did help to highlight specific changes in science teaching expectations, exploring the biology specifications from one of the more popular exam boards (AQA) will help to represent how those changes in expectations can lead to changes in what is taught in classrooms (Crisp & Greatorex, 2022; Jerrim, 2023). AQA was chosen for this examination as it represents the largest exam board in the UK and has a high utilization rate at the GCSE level (Maratos et al., 2023).

### 4.2.1 2012 AQA GCSE Biology Specifications for Exams June 2014 and Onward

The 2012 AQA GCSE Biology Specifications were released as an updated version of specifications influenced by the 2007 National Curriculum for England (AQA, 2012). This version would be the last AQA would release before the completion of the 2010-2013 Revision processes that ended in 2014. As this is the case, this version of specifications is based on the "How Science Works" curriculum that predates the introduction of specific genomics language into the National Curriculum.

The biology content is divided into three units. Content surrounding the teaching of genetics and inheritance first comes up in Unit 1: Section 1.7 Genetic Variation and its Control. The section introduction can be found below:

> "There are not only differences between different species of plants and animals but also between individuals of the same species. These differences are due partly to the information in the cells they have inherited from their parents and partly to the different environments in which the individuals live and grow. Asexual reproduction can be used to produce individuals that are genetically identical to their parent. Scientists can now add, remove or change genes to produce the plants and animals they want."

(AQA, 2012)

The section of the specification states students should be able to use their skills, knowledge and understanding to:

- interpret information about cloning techniques and genetic engineering techniques
- make informed judgements about the economic, social and ethical issues concerning cloning and genetic engineering, including genetically modified (GM) crops.

(AQA, 2012)

In this section of the specification, student learning is focused on the role of genes in determining physical characteristics (B1.7.1 Why Organisms are Different) and how reproductive processes pass genes from parent to offspring (B1.7.2 Reproduction). This leads to variation amongst individuals within a species. Students learn that research into these processes have led to the discovery of genetics techniques such as genetic engineering and the development of genetically modified crops.

The discussion of inheritance and genetics continues in Unit 2: Section 2.7 Cell Division and Inheritance. The short introduction outlines a very specific set of ideas:

> "Characteristics are passed on from one generation to the next in both plants and animals. Simple genetic diagrams can be used to show this. There are ethical considerations in treating genetic disorders."
>
> (AQA, 2012)

Per the document, students should use their skills, knowledge, and understanding to:

- explain why Mendel proposed the idea of separately inherited factors and why the importance of this discovery was not recognised until after his death
- interpret genetic diagrams, including family trees
- construct genetic diagrams of monohybrid crosses and predict the outcomes of monohybrid crosses and be able to use the terms homozygous, heterozygous, phenotype and genotype
- predict and/or explain the outcome of crosses between individuals for each possible combination of dominant and recessive alleles of the same gene

- make informed judgements about the social and ethical issues concerning the use of stem cells from embryos in medical research and treatments
- make informed judgements about the economic, social and ethical issues concerning embryo screening.

(AQA, 2012)

The specifications then break down into three sub-sections. The student is meant to learn about the processes and results of cell division (B2.7.1 Cell Division). Here the specifications outline what students are meant to learn about processes such as mitosis, meiosis, cell differentiation, and fertilization and the role genetic materials such as DNA play in them. Subsection B2.7.2 Genetic Variation contains the most focus on inheritance as it concentrates on several elements of the Classical Model. Here students are meant to explore how the recombination of alleles from two parents gives rise to offspring with traits of both parents as well as the interplay of DNA, chromosomes, genes, and alleles in this process. Sub-section B2.7.3 Genetic Disorders continues the study of Classical Genetics as students explore the concept of inherited diseases with emphasis on single gene disorders such as polydactyly, a disorder passed from a single parent to offspring, and cystic fibrosis, a condition only passed to offspring if both parents carry the specific alleles.

### 4.2.2 2016 AQA GCSE Biology Specifications for Exams June 2018 and Onward

In 2016, AQA released a new version of their GCSE Specification in Biology in response to the newly revised National Curriculum for England. In many ways, this version is quite similar to the 2014 Specifications but there are some distinct differences in the realm of inheritance and genetics. While genetics is still linked with processes within the cell, the two are not found within the same section with the majority of content involving inheritance found in section 4.6 Inheritance, Variation, and Evolution while cell processes are found in section 4.1 Cell Biology. Section 4.1 does make some mentions to genetic concepts such as DNA and genes, but the bulk of these concepts are explored in section 4.6. The introduction to Section 4.6 Inheritance, Variation, and Evolution states:

> "In this section we (students) will discover how the number of chromosomes are halved during meiosis and then combined with new genes from the sexual partner to produce unique offspring. Gene mutations occur continuously and on rare occasions can affect the functioning of the animal or plant. These mutations may be damaging and lead to a number of genetic disorders or death. Very rarely a new mutation can be beneficial and consequently, lead to increased fitness in the individual. Variation generated by mutations and sexual reproduction is the basis for natural selection; this is how species evolve.

> An understanding of these processes has allowed scientists to intervene through selective breeding to produce livestock with favoured characteristics. Once new varieties of plants or animals have been produced it is possible to clone individuals to produce larger numbers of identical individuals all carrying the favourable characteristic.
>
> Scientists have now discovered how to take genes from one species and introduce them into the genome of another by a process called genetic engineering. In spite of the huge potential benefits that this technology can offer, genetic modification still remains highly controversial."
>
> (AQA, 2016)

As with the 2012 Specification, the 2016 Specification also divides the content into subsections with specific areas of focus, although with a greater degree of specificity. Subsection 4.6.1 Reproduction focuses on the process of sexual and asexual reproduction. The subsection explores the processes such as Meiosis and Fertilization and how these processes contribute to variation amongst a species during sexual reproduction but result in genetic clones during asexual reproduction This subsection is where you find specific references to the genome (4.6.1.4 DNA and the Genome):

> Students should be able to discuss the importance of understanding the human genome. This is limited to the:
>
> - search for genes linked to different types of disease
> - understanding and treatment of inherited disorders
> - use in tracing human migration patterns from the past.
>
> (AQA, 2016)

This sub-section also includes references to the Classical Model of genetics such as the role of genes, alleles, dominance/recessiveness, genotype/phenotype, and inherited disorders. As with the previous specification, this version continues to emphasize single gene disorders.

The remainder of the section continues to explore the role of inheritance in various biological contexts. Sub-section 4.6.2 Variation and Evolution, looks at the role of genes in causing variation amongst populations and how this contributes to evolution through natural selection. Here students are also introduced to the idea that the genome and its interaction with the environment influence the phenotype of an organism. This subsection also introduces students to human practices in genetics such as genetic engineering, selective breeding, and the implications of cloning. Sub-section 4.6.3 The Development of Understanding Genetics and Evolution, further explores the links between inheritance, genetics, and Darwin's Theory of Evolution with some emphasis placed on Mendel's experiments and their impact on inheritance knowledge. Sub-section 4.6.4 Classification of Living

Organisms, explores the processes by which organisms are classified and what this reveals about the history of living things.

### 4.2.3 Comparing the Changes

Comparing the two documents does give some insight into how AQA adjusted their exam specifications based on the different curricula documents (2007 National Curriculum Science PoS vs the 2014 National Curriculum Science PoS). As stated previously, textbooks and teacher materials are often created based on what appears in the National Curriculum so comparing the documents helps to highlight changes. Table 4.1 shows the sub-section headings which provide a good initial understanding of the changes made:

**Table 4.1 Inheritance in AQA GCSE Specifications for Biology (Sub-sections)**

| | |
|---|---|
| **2012 (2007 NC)** | ***Unit 1: Section 1.7 Genetic Variation and its Control***<br>B1.7.1 Why Organisms are Different<br>B1.7.2 Reproduction<br><br>***Unit 2: Section 2.7 Cell Division and Inheritance***<br>B2.7.1 Cell Division<br>B2.7.2 Genetic Variation<br>B2.7.3 Genetic Disorders |
| **2016 (2014 NC)** | ***4.6 Inheritance, Variation, and Evolution***<br>4.6.1 Reproduction<br>4.6.2 Variation and Evolution<br>4.6.3 The Development of Understanding Genetics and Evolution<br>4.6.4 Classification of Living Organisms |

Excerpts from the AQA 2012, 2016 GCSE Specifications for Biology

The sub-sections give some indication as to how the specifications were altered to reflect changes in the National Curriculum PoS. For ease of comparison, Table 4.2 provides both Key Stages 3 and 4 PoS of the 2007 and 2013/14 versions of the National Curriculum:

**Table 4.2** ***Inheritance in the National Curriculum Science PoS***

| | |
|---|---|
| **2007** | *Key Stage 3*<br>*All living things show variation, can be classified, and are interdependent, interacting with each other and their environment<br>*Behaviour is the influenced by internal and external factors and can be investigated and measured<br><br>*Key Stage 4*<br>*Human health is affected by a range of environmental and inherited factors, by the use and misuse of drugs, and by medical treatments |
| **2013/2014** | *Key Stage 3*<br>*Heredity as the process by which genetic information is transmitted from one generation to the next<br>*A simple model of chromosomes, genes and DNA in heredity, including the part played by Watson, Crick, Wilkins and Franklin in the development of the DNA model<br>*Differences between species<br>*The variation between individuals within a species being continuous or discontinuous,<br>*To include measurement and graphical representation of variation<br>*The variation between species and between individuals of the same species means some organisms compete more successfully, which can drive natural selection<br>*Changes in the environment may leave individuals within a species, and some entire species, less well adapted to compete successfully and reproduce, which in turn may lead to extinction<br>*The importance of maintaining biodiversity and the use of gene banks to preserve hereditary material<br><br>*Key Stage 4*<br>*The genome as the entire genetic material of an organism<br>*How the genome, and its interaction with the environment, influence the development of the phenotype of an organism<br>*The potential impact of genomics on medicine<br>*Most phenotypic features being the result of multiple, rather than single, genes<br>*Single gene inheritance and single gene crosses with dominant and recessive phenotypes<br>*Sex determination in humans<br>*Genetic variation in populations of a species<br>*The process of natural selection leading to evolution<br>*The evidence for evolution<br>*Developments in biology affecting classification<br>*The importance of selective breeding of plants and animals in agriculture<br>*The uses of modern biotechnology including gene technology; some of the practical and ethical considerations of modern biotechnology |

Excerpts from the National Curriculum for England

Note that the 2012 AQA Specs are based on the 2007 National Curriculum Science PoS and the 2016 AQA Specs are based on the 2013/14 National Curriculum Science PoS. Changes based on the alterations to the National Curriculum are evident. While the 2007 National Curriculum Science PoS was broad and left room for teachers to make some decisions about what was emphasized, the 2013/14 National Curriculum Science PoS are far more precise. The AQA Specifications share that same quality. For further examination, Table 4.3 provides the Introductions for the Inheritance content from the AQA Specifications for Biology in 2012 and 2016:

**Table 4.3** ***Inheritance in AQA GCSE Specifications for Biology (Introductions)***

| | |
|---|---|
| **2012 (2007 NC)** | ***Unit 1: Section 1.7 Genetic Variation and its Control***<br>There are not only differences between different species of plants and animals but also between individuals of the same species. These differences are due partly to the information in the cells they have inherited from their parents and partly to the different environments in which the individuals live and grow. Asexual reproduction can be used to produce individuals that are genetically identical to their parent. Scientists can now add, remove or change genes to produce the plants and animals they want.<br><br>***Unit 2: Section 2.7 Cell Division and Inheritance***<br>Characteristics are passed on from one generation to the next in both plants and animals. Simple genetic diagrams can be used to show this. There are ethical considerations in treating genetic disorders. |
| **2016 (2014 NC)** | ***4.6 Inheritance, Variation, and Evolution***<br>In this section we (students) will discover how the number of chromosomes are halved during meiosis and then combined with new genes from the sexual partner to produce unique offspring. Gene mutations occur continuously and on rare occasions can affect the functioning of the animal or plant. These mutations may be damaging and lead to a number of genetic disorders or death. Very rarely a new mutation can be beneficial and consequently, lead to increased fitness in the individual. Variation generated by mutations and sexual reproduction is the basis for natural selection; this is how species evolve.<br><br>An understanding of these processes has allowed scientists to intervene through selective breeding to produce livestock with favoured characteristics. Once new varieties of plants or animals have been produced it is possible to clone individuals to produce larger numbers of identical individuals all carrying the favourable characteristic.<br><br>Scientists have now discovered how to take genes from one species and introduce them into the genome of another by a process called genetic engineering. In spite of the huge potential benefits that this technology can |

Excerpts from the AQA 2012, 2016 GCSE Specifications for Biology

While the 2012 Specification introduction to Inheritance uses language such as "information" to convey the passing of DNA from parent to offspring, the 2016 introduction is far more precise incorporating specific terms such as "chromosomes" and "genes". The 2016 Introduction also goes further in describing specific areas of genetic research while the 2012 Introduction makes less detailed remarks, once again mirroring the differences in approach in the curricula they are taken from.

While both specifications offer similar topics such as variation and reproduction, the 2016 Specification is more targeted in its approach to outlining what students are meant to learn. The introduction of genomics language into the National Curriculum is also prevalent with the appearance of genomics specific language into the 2016 Specifications (4.6.1.4 DNA and the Genome). The influence of the National Curriculum on the exam specifications is clear.

The National Curriculum PoS forms the basis for what is meant to be taught in schools. Although it is no longer mandatory in all UK schools, it does continue to influence what is tested which plays a role in determining what teachers emphasize in their teaching. If the processes of determining curriculum also represent the selection of knowledge deemed appropriate for students leaving secondary school, then exploring how that knowledge is selected and transformed represents some aspects of socialization. As outlined previously, the curriculum represents the knowledge students need to acquire before leaving compulsory schooling. If this is the case, then is the selection of knowledge reflective of current values in society or previous ones? Who holds the authority in the selection of knowledge? Are the same authorities responsible for transforming the knowledge? These are all questions that require examining and the current study looks to explore them.

## 4.3 Summary

In this chapter I have established the links between curriculum, teaching resources, and classroom teaching. While curricula like the National Curriculum PoS outline what students are meant to be learning, it often more influential in the development teaching materials, textbooks, and in this specific case, exam specifications. The links between exam specifications and what is taught in secondary courses have been well established in the literature. Although concepts can appear in the National Curriculum PoS, what is actually taught and emphasized is often based on what is assessed.

Based on these links, I examined the AQA Exam Specifications created both before and after the 2010-2013 Revision to the National Curriculum to determine if changes made in during the 2010-2013 Revision were reflected in the biology exam specifications of one of the more widely used exam boards. While exploring the AQA exam specifications for Biology, it was observed that changes made in both the structure and content made to the National Curriculum Science PoSs were reflected in the new specifications. As this is the case, it can be inferred that teachers who take advantage of these resources also take note of the shifts, which may affect how they approach their classroom instruction.

The next chapter will focus on the theoretical lens utilized in this study of how new knowledge becomes included in the curriculum.

# Chapter 5: Bourdieu, Bernstein, and the Transformation of Knowledge

As outlined in the previously, the research questions of this study focus on exploring how genomics came to be introduced into the National Curriculum for England and what this may reveal about the processes that transform new research knowledge into science curricula and lesson. The study of curriculum and its processes of development require an approach that allows for the collection and analysis of both the societal and cultural effects that may provide context for decision-making. One must also consider the processes that transform research knowledge into curricula. In this chapter, I will explore a number of approaches to curriculum study, each considering the social, cultural, and political influences on curriculum development. I will outline the theoretical lens on which my study is based and consider the strengths and drawbacks of examining the case this way.

## 5.1 Curriculum Theory

At cursory glance, it would seem that curriculum theory would be the most suitable approach to addressing the current case. Defined as the interdisciplinary study of the historical, political, and social dimensions of curriculum, there are many different approaches to its study (Coşkun Yaşar & Aslan, 2021). At its core, curriculum theory and curriculum theorists are concerned with the factors that shape curriculum. Of great importance to the study of curriculum theory is the idea that curriculum itself is not created nor exists in a vacuum (Pacala, 2023). As curriculum is defined both the knowledge deemed valuable to members entering society or the educational policies surrounding teaching, it important to study and explore the numerous factors that contribute to its creation and maintenance (Herrick & Tyler, 1950). Curriculum theorists devote themselves to this study by exploring the past in attempts to understand the future.

Curriculum theorists tend to focus on the “what” and “why” of curriculum. Analysis typically centers on examining the efforts made when people deal with the curriculum and the questions and problems of its impact (Tahirsylaj, 2019; Young, 2013). As stated previously, numerous factors affect curriculum. Curricula are the result of human processes and as such are affected by things like culture, politics, religion, sex/gender, morality, race, class, and several others. Employing a wide variety of methodological approaches, curriculum theorists have developed several ways of thinking about the impact of society on curriculum and vice versa.

Many prominent individuals have contributed ideas about the nature of curriculum to this discipline. Researchers such as John Dewey, Maria Montessori, Michael Schiro, and Michael Young have made significant contributions to the field (Apple, 2018; Pratt, 2022; Young, 2013). In addition to the societal and cultural factors that affect and pervade discourse surrounding the curriculum, significant attention is often paid to how existing theories are classified. There are numerous theories about the role developed curricula play.

Given the wide-ranging views of the role of curriculum, the different ways of classifying and categorizing curriculum theories also plays a significant role in the discipline. Through the classification of theory, we can start to see how curriculum researchers view the many variables that affect the processes. Eisner and Vallance (1974) classified curriculum theories based on whether they felt the theory emphasized a commitment to western culture (Academic Rationale), adhered to some predetermined goals or standards (Technology), focused on mental processes (Cognitive Processes), or focused on processes that ensure individual freedom (Self Actualization). McNeil's (1977) classifications were based on whether the theory was concerned with providing students with useful experiences (Humanist), improving social values and critical thinking (Social Reconstruction), or details of a particular discipline (Academic). Note that both systems of classification are based on exploring the role of curricula in the lives of the student and in the broader context of societal impact.

More recent curricula theorems continue this trend. Posner (1995) viewed curriculum theories as focused on either the transferal of cultural heritage between generations (Traditional) or students building their own sense of knowledge in attempts to make it more meaningful. Null (2016) saw curriculum theories as designed around processes that raise intellectually and morally complete individuals (Liberal), seek accountability through student assessment/performance based on the roles students may play as adults (Systematic), allow students to gain emancipatory knowledge to develop new ways of thinking (Existentialist), create agents of social change and reconstruction (Radical), develop individuals who will find practical solutions to societal problems through deliberation (Deliberative).

When viewed together, there seems to be some overlap between the ways theorists view the curriculum and its relationships with both students and society as a whole. Taken together these theorists would seem to posit that there are four ways of viewing curricula. For the sake of this study, it may be useful to develop my own system for viewing curriculum theories. Based on this I have devised four categories of curriculum theory.

Firstly, there are the Skill-centered theories. These posit that curricular theory should be based viewing the curriculum as observable, assessable skills focused on preparing students for life after compulsory schooling. In this viewpoint curriculum can be seen as a way to determine if students are learning and exhibiting the skills needed to prosper after finishing school. Eisner and Vallance's concepts of Technology curriculum theories and Null's concept of the Systematic curriculum theories fit this description with their emphasis on practical skills and assessment.

Secondly there are the Individual-centered theories which posit that curriculum theories should be focused on the needs of the individual student to acquire experiences that will build autonomy. The goal here is for the student to learn in hopes of developing their own notions of thinking and considering the world. Curricula should be less about developing specific skills to prepare for life and more about developing the ability analyze information and draw conclusions to develop new ideas and solutions. McNeil's Humanist and Posner's Constructivist concepts fit here.

Thirdly there are the Society-centered theories which see curricula as centered on the idea that curriculum should arm students with the knowledge and skills to understand and solve societal problems. There is some link between the Individual-centered and Society-centered approaches but where the one focuses on the development of individual skills, the other focuses on a more collective approach incorporating elements of societal impact over individual impact. McNeil's Social Reconstructivitst and Null's Radical theories are best described through this lens.

Finally, Cultural-centered theories posit that curriculum should viewed through a lens centered on processes of acculturation of students into the knowledge of specific disciplines. Students are primed to become contributors to the culture of specific social and knowledge disciplines to someday contribute new ideas and reevaluate old ones. Looking at the wealth of curriculum theory allows for highlighting how diverse thought and conception within the field can be. It also highlights what some may see it as criticism of the field and while I think curriculum theory informs the current study, its limitations make it unideal for examining the current case.

Curriculum theory is most often applied as a means for exploring the numerous ways curricula impact and is impacted by historical and social factors. As many theories within this space cover the relationship between curriculum and society, there is a good argument for using any of them as a lens for gathering and analyzing data in the pursuit of my research questions. The problem is that curriculum theorists often view curriculum as a finished product. The goal is to view impact on what is often already created and implemented. Even when curriculum theory is applied to processes of curriculum development the goal is to measure how the process of development is impacted by societal factors. The current case not only focuses on curriculum development as a process centered on building a document, but also on those processes that select, transform, and distribute new knowledge to school age children. As such, while curriculum theory inevitably informs the current study it may not offer the most appropriate lens for investigating the nature of these processes or the factors that impact them.

## 5.2 Bourdieu's Theory of Practice

Bourdieu's work focuses on social practice and the ways that social *agents*, members of a particular social system, attempt to navigate through social fields, arenas where social agents compete for resources (Grenfell & James, 1998). Bourdieu theorizes that this navigation occurs through the interaction of three primary concepts: Habitus, capital, and field (Bourdieu, 1987). Exploring the interplay of these three concepts can be used to study a number of cultural and social phenomena across various areas in society including education, sports, and art. Each concept lends a distinctive contribution to the constantly changing dynamics of social practice and investigating each allows one to view how these subtle nuances contribute to the social landscape.

In Bourdieu's work, the concepts of field, habitus, and capital are at the center of many of the conscious and unconscious decision-making processes of social agents. At the core of the social agent is the habitus, a term coined by Bourdieu. Habitus can be described as a set of acquired dispositions of thought, behavior, and taste, which is said to constitute the link between social structures and social practice or social action (Scott & Marshall, 2009). Bourdieu's concept of habitus is his way of describing the elements of one's past experiences that drive responses and reactions, proclivities and tendencies, and a host of various other aspects of one's being. A number of elements about a person including the type of music they listen to, the way they dress, and even their responses to social stimuli, can all be attributed to aspects of an individual's habitus. These "tastes" reveal a person's comfort in a given social arena.

The habitus is developed throughout the life experiences of the individual. Social interactions during life contribute to one's habitus, intentionally or unintentionally, eventually shaping views and dispositions. These views and dispositions manifest themselves in the behaviors of the individual and the individual's nature. Every interaction shapes and molds the habitus, leading to one's responses to social stimuli. Wacquant (2011) explains that habitus proposes that human agents are historical animals who carry within their bodies acquired sensibilities that are the products of their past social experiences.

Another important aspect of Bourdieu's theory of practice is the concept of *field*. Field can be described as the social arena in which power struggles and conflict take place and in which specific kinds of capital are at stake and certain forms of habitus or dispositions are fitted for success (Gaventa, 2003). It is the place where individuals compete for various forms of *capital*. Capital in this sense can come in various forms such as social, economic, and even cultural capital. Created by Bourdieu, cultural capital refers to the symbols, ideas, tastes, and preferences that can be strategically used as resources in social action (Scott & Marshall, 2009). Fields are very diverse, and each has its own set of rules, knowledge and forms of capital and familiarity. Understanding these "rules" allows one to navigate the field, obtaining capital in attempts to control what has value and who has power. It is in this concept of "fields of play" that social interactions determine who is able to obtain power, here denoted by the various forms of capital. In the transformation of genomics knowledge into one for secondary science teaching and learning, this capital can take multiple forms such as securing time to consult with agents of more influential status on the field or the ability to influence the direction of curriculum development in certain areas.

It is in this struggle for capital that we find the essence of Bourdieu's work. Social agents sharing a field all have positions. These positions are intertwined with the habitus of an individual and are indicative of a social agent's ability to use resources to obtain capital on that field. The individuals best equipped to navigate the field, those with the best positioning, typically have the least resistance in acquiring capital. Navigating the field requires certain knowledge of the rules and nuances of the field. Understanding these rules makes it easier for one to navigate their position on the field. The rules to any given field may be overt and easily obtained but are often hidden from plain sight. So how does one acquire knowledge of these unwritten rules?

Bourdieu (1977) uses the term doxa to describe the ideas taken for granted in any particular society or the experiences which appear to the social world as self-evident. These are the commonly held beliefs, perhaps even truths in a sense, which have been ingrained in an individual by social interaction. These doxa can reveal a significant amount about an individual's habitus, and thus their positioning on the field. In a sense, the doxa of a field can represent the natures and dispositions that are deemed appropriate for that field. Individuals who understand the doxa of the field often understand the nuances expected of one in that particular field and therefore have greater positioning and some advantage in obtaining forms of capital. For example, those seeking to obtain capital on the field of politics may use certain language and dress in specific styles to signify their “belonging” to a political class. This reveals their habitus to other players providing an avenue to obtain capital with likeminded agents. In this case the manner of speak and dress are considered doxa of the field that are determined by agents with greater positioning.

Bourdieu posits that individuals with similar habitus group together, recognizing each other by various doxa that make up the field (Bourdieu, 1977). By sharing in an understanding of the social nuances of the field, a new entrant to the social arena is able to reveal their habitus, thus allying themself with others with similar habitus. Those who are allied with individuals in more powerful positions, positions that have an easier ability to acquire capital, reap the benefits of the groups and are thus introduced to the dispositions and behaviors that make accumulating capital easier. In a sense, these groupings introduce new social agents to the field and, based on their habitus, introduce them to the rules of field, both hidden and unhidden.

Bourdieu likened this interplay of habitus, field, and the pursuit of capital to a “game” (Bourdieu, 1990a). Those who enter a new field understanding the rules of other similar fields may find themselves in the company of other agents who help them to navigate, recognizing them for their habitus and passing on the “unwritten rules” of the game. This familiarity allows greater positioning and more opportunities to obtain capital, which can be used to obtain greater positioning still. Some individuals have greater capability to play the game than others.

Bourdieu's Theory of Practice represents a way of examining the power structures behind the creation of curriculum. As noted previously, curriculum development can be seen as a policymaking act and as such is carried out with the influence of many individuals and organizations, each bringing their own perspective to the process. Bourdieu's concepts of habitus and capital provide a lens for considering how experiences and perspectives affect what is perceived as valuable, providing a look into desired outcomes. Bourdieu also provides a way of considering how culture is disseminated through curriculum development. Bourdieu's work has been used to study curriculum in the past (Collins, 2000; Franz et al., 2022; Martínez-Bello et al., 2021; Whigham et al., 2020). Martinez-Bello et al. used Bourdieu's theory of practice to study inequalities stemming from the development of teaching materials from curricula documents. Whigham et al. utilized Bourdieu as a lens for examining stratification in the physical education curriculum for England. Franz et al. used Bourdieu's concepts to study the effects of curriculum reform.

There can be some drawbacks to employing Bourdieu's theory of practice in the study of curriculum. Bourdieu's tools were not originally intended to be used as lens for examining curriculum. As stated previously, Bourdieu's initial focus was exploring systems of inequality and the power structures that lead to them. While Bourdieu's concepts of habitus and capital help to outline the competitions between agents, it is often used to represent inequality in power in curriculum as a product as opposed to a process (Grenfell & Lebaron, 2014; Harker & May, 1993; Power, 1999). Like some aspects of the aforementioned Curriculum Theory, Bourdieu's thinking tools can help to outline the connections between societal, cultural, and power influences on curriculum documents after the development process but there may be more appropriate theoretical approaches for the current study and its goal of examining how new research becomes integrated into curricula.

Of course, curricula are not created in a vacuum. As established previously, societal and cultural factors ultimately have impact on curriculum development and given the role power structures play in policy development as a whole, Bourdieu's concepts of habitus, field, and capital do represent a good way of exploring some aspects of participant data. As such, the current study utilized Bourdieu's concepts as a means of analyzing aspects such as agent motivation from the data collected from participants. While this provided a good way to review the collected data in some ways, another lens with a focus on the process of curriculum development as opposed to the power structures would be needed to examine the research questions of the current study.

### 5.3 Bernstein and the Pedagogic Device

While a Bourdieusian approach emphasizes the relationships and interactions that result from curriculum development, Basil Bernstein's Pedagogic Device offers a model for analyzing the processes by which discipline specific knowledge is converted to pedagogic communication (curriculum documents, textbooks, and lessons) and school knowledge (Singh, 2002). Bernstein theorized that the processes that determine pedagogic communication hold great sway in determining what ideas are valuable to members of society. Developed over the later stages of his career, the pedagogic device offers a way for viewing how some aspects of newly developed knowledge become pedagogic communication in classrooms and in turn how these processes are affected by political and social systems of power. Bernstein (2004) outlines the process of converting knowledge as following a series of rules or principles that guide how knowledge is produced, distributed, and evaluated. In the following sections, I will review how Bernstein's pedagogic device has been used as a means of analyzing and organizing data surrounding the development of curricula and why this approach offers an effective tool for examining the introduction of genomics into the National Curriculum.

### 5.3.1 The Pedagogic Device

The pedagogic device provides analytical tools to examine the social and political levers and processes of educational change through curriculum development (Loughland & Sriprakash, 2016). The device opens a window to explore these processes from the macro level, with statewide policymaking at the national level, or at the meso level – local authorities making decisions about what is to be taught in classrooms.

Bernstein characterized knowledge arising from research centers as eventually existing in two forms (Castells, 2011). The *mundane*, sometimes referred to as common knowledge, represents a form of knowledge to be used in the everyday world. Mundane knowledge can be described as the knowledge driven by everyday thought and daily interactions in the world among people (Muller & Taylor, 1995). This is the knowledge of the everyday layperson or non-specialist, developed for use outside specialist arenas. Although, or perhaps because, the mundane is for use in widespread society, it is affected by the constantly changing tastes and ideologies of society. Bernstein considered mundane knowledge to be consistently in flux and heavily influenced by widespread social views and as such, the mundane often changes when society changes.

In contrast to the mundane is the *esoteric,* or domain-specific knowledge. Esoteric knowledge refers to the disciplinary knowledge used by experts in the field to convey new knowledge and ideas to other experts. It is the knowledge born out of research centers meant to be used in specialist circles by individuals with specialist expertise. All newly produced knowledge essentially begins as esoteric with competition (see below) determining what aspects are meant to become the mundane.

Bernstein (2000) referred to this process of transforming esoteric, expert knowledge into pedagogic communication, such as curriculum documents and classroom lessons, as *recontextualisation*. For example, genomics knowledge, as constituted in research centers, requires altering before becoming a part of secondary science courses. During this process of alteration, decisions are made regarding what aspects of genomics knowledge are suitable for secondary students, what language can be used to convey it, and the criteria for determining if students have achieved adequate understanding. Answering these questions leads to the development of curriculum documents, textbooks, and teacher/student resources that will be employed in teaching students the newly altered forms of genomics knowledge, thus transforming the esoteric into the mundane. Similar processes often occur for content development across all subjects.

Bernstein (2004) sees these processes as competitions that result from numerous interactions between different groups and organizations, or *agents*. These competitions seek to control a specific set of principles or *rules* that regulate some aspects of education and represent Bernstein's attempts to explain stability and uniformity across national educational systems despite differences in social statuses and backgrounds. Bernstein saw the pedagogic device as a means of explaining how ideas of society change or propagate based on the interactions of individuals in educational fields and other fields adjacent to education such as politics and policymaking (Singh, 2002). Viewed through the pedagogic device, new knowledge and ideas go through a series of processes and conversions, moving them from a discourse suited only for expert use, to one suitable for consumption by lay members of society. Those with the power to control these processes, or competitions, control what knowledge is deemed important or valuable to society and, therefore, needs to be taught in schooling institutions. For Bernstein, these competitions involving individuals in fields adjacent to education act as a means propagating social ideas through this process of recontextualisation and distribution of newly produced knowledge and, in doing so, establishes some aspects of social norms and how that knowledge is viewed (Singh, 2002).

Competitions often manifest themselves in the determination of a set of three distinct rules or principles of the pedagogic device. The development, contestation, and revision of each set of rules in the pedagogic device is an ongoing process. In various social arenas, organizations or groups compete for the opportunity to determine the *distribution (*which groups receive new knowledge*)*, *recontextualising* (what kind of knowledge is meant for school curricula and how that knowledge is converted into pedagogic communication), and *evaluative* (what constitutes good pedagogy and valid acquisition of newly recontextualised knowledge) rules for emerging knowledge. These competitions can represent several processes with a number of competing organizations. Bernstein (2004) referred to these competing organizations and groups as *agents* and the arenas of competition as *fields*. Bernstein uses the term field in a similar fashion to Bourdieu, namely a social space of conflict and competition where agents compete for resources, referred to as capital by Bourdieu, to establish the authority to regulate/dictate the guiding principles of the space. In this particular case, the agents vie for the opportunities to control the rules of the pedagogic device and, by extension, what knowledge is suitable for teaching in schools and therefore important for most members of society. Bernstein identifies three fields for these competitions each considered below: production, recontextualisation, and reproduction.

### *5.3.2 Field of Knowledge Production*

On the field of knowledge production, new knowledge is developed in research centers and institutions of higher learning with competition determining what aspects of the new knowledge warrant teaching in school and thus recontextualisation (Singh, 2002). Bernstein distinguishes the elements of new knowledge worthy of being taught in schools from those that are not (Wright &

Froehlich, 2009). The term *thinkable* refers to that newly produced knowledge that will be taught in school and the term *unthinkable* represents knowledge left out of school. The field of production is primarily involved with the development of new knowledge and distinguishing the thinkable from the unthinkable. In this field, agents compete to determine the *distribution rules* that determine who is meant to receive newly developed knowledge and whether that should happen through schools, separating the thinkable from the unthinkable.

### *5.3.3 Field of Knowledge Recontextualisation*

Knowledge deemed thinkable from the field of production is then passed to the field of recontextualisation. Recontextualisation is the process whereby expert specific, esoteric knowledge actually becomes pedagogic communication such as that found in curriculum documents, classroom lessons, and discourse. The field of recontextualisation is primarily concerned with the processes that specifically transform the esoteric into teaching practices, resources, and pedagogic communication and discourse. Over time, the process of recontextualisation converts the esoteric into the mundane. Bernstein saw this process occurring in two ways and divided the field into two sub-fields: the *official recontextualising field* (ORF) and the *pedagogic recontextualising field* (PRF) (Bernstein, 2004). These fields work to convert knowledge into pedagogic communication. The basis for curricular documents, textbooks, teacher resources, and many other aspects of the educational practice are based on the outcomes of these fields. In both fields, agents compete to determine the *recontextualising rules* which determine the specific formation of pedagogic communication.

The ORF constitutes the agencies of the State and local educational authorities with their research and systems of inspection (Bernstein, 1990). Here, State-controlled bodies regulate the processes that recontextualises new knowledge and the instructional practices preferred in presenting it. This regulation occurs through the production of curriculum documents, assessment, and systems of inspection and evaluation. Through these processes, State agencies, or *official agents,* wield some control over what knowledge is taught in secondary courses and what resources and practices are needed/preferred in teaching it.

In contrast to the ORF is the PRF. While the former represents the State and local processes that recontextualise knowledge, the latter is comprised of university departments of education and specialized media in education in addition to their readers and advisors (Bernstein, 1990). In this sub-field, *pedagogic agents* seek to influence what knowledge is taught in secondary courses through direct interactions with teachers and individuals through training and the development of teacher resources. While the PRF is constituted primarily of education specialists, it may extend to agents not specialized in education, especially if these agents may hold some manner of influence with the ORF.

### *5.3.4 Field of Knowledge Reproduction*

Newly recontextualised knowledge in the form of pedagogic communication from the ORF and PRF moves to the field of reproduction. In this field, newly recontextualised knowledge is presented to new audiences in the form of textbooks, curriculum documents, teaching resources and pedagogic practices. Teachers then use these pedagogic communications to instruct their students, who are then assessed on their ability to reproduce the taught knowledge. This assessment of reproduction can take several different forms including the personal development of teacher assessment tools such as assignments and quizzes at the micro level or through national testing schemes such as GCSEs and A-Levels at the macro level. The nature of what constitutes valid acquisition and reproduction of newly recontextualised knowledge typically forms the basis for competition amongst agents inhabiting this field.

Here, Bernstein observes the pedagogic communication developed on the twin fields of official and pedagogic recontextualisation in the form of textbooks and curriculum documents undergoes two more processes of recontextualisation (Bernstein, 2004). Firstly, teachers convert the newly recontextualised pedagogic communication into classroom experiences such as lessons, assignments, and assessments so that the new knowledge can be presented to students. Secondly, students take these experiences and, with the guidance of teachers, develop their own understanding about the new knowledge presented to them. The student's understanding of this new knowledge is often based on their background, developing personal ideologies, and values. These factors also play a role in the value the student places on new knowledge. From here, the student's ability to reproduce their understanding of the new knowledge is assessed.

The field of reproduction represents the culmination of several processes of recontextualisation. It encompasses much of formal schooling and, as such, involves the interactions of several agents at the macro (National), meso (Local Authorities), and micro (School Leadership) levels. It is also the point at which students first become a part of the processes that convert knowledge. This is important to note, as prior to this point, all processes of recontextualisation have little to no involvement from students. Due to the widespread importance of schools, the primary competitions in this field typically revolve around the authority to determine the *evaluative rules* which indicate who is capable of presenting new knowledge to students and what constitutes valid acquisition of said knowledge. While the field of recontextualisation determines how new knowledge is transformed into curricula and documents outlining *what* is to be taught, the field of reproduction is concerned with *how* the new knowledge is taught and *how* it is determined that students have exhibited adequate learning. Regulating the answers to these questions can give an agent some degree of influence in what ideas and tastes are consistently propagated in society through schooling. For example, while the National Curriculum's PoS (DfE, 2014) outlines what aspects of inheritance are meant to be taught in secondary biology courses, different processes determine what represents good practice in teaching these aspects of inheritance and how students are meant to exhibit they have learned them.

#### *5.3.5 Critique and Criticism of the Pedagogic Device and its Application*

Bernstein's Pedagogic Device represents a framework used to study the development of curriculum and its influences (Barrett, 2017; Singh, 2002;

Sriprakash, 2011). The use of fields as a space to discuss the development of pedagogic discourse on the production, recontextualisation, and reproduction of knowledge through the establishment of rules, have provided many with a way of interpreting the real-world development of pedagogic communication. Researchers have used the theory as a lens for studying curriculum development across multiple disciplines, levels, and environments. The ability to apply the theory across such wide-ranging phenomena remains one of its biggest strengths.

The pedagogic device is not without its weaknesses. Researchers have highlighted some levels of contradiction when considering the processes that govern what occurs between fields and increasing difficulty specifically outlining how the rules are established across multiple levels, i.e., national or local (Lamnias, 2002; Lim, 2017). The current study looks to explore these viewpoints as it examines how contemporary curriculum development at the national level can potentially be affected by the interactions of many organizations simultaneously that the traditional view of the pedagogic device as hierarchical requires re-examination, an observation proposed in some literature

Curriculum development at the national level has always been a process driven by government and, therefore, susceptible to the changing political landscape (Garratt & Forrester, 2012; Hacker & Pierson, 2010). Each change in government is often accompanied by changes in legislative priorities and policy disputes. As the development of curriculum remains a policy process, governments will continue to seek likeminded voices to champion their ideas of what members of society need to learn through compulsory schooling (Apple, 2018; Ball, 2009).

## 5.4 Bernstein and Bourdieu

Bernstein's idea of the Pedagogic Device has much in common with Bourdieu's Theory of Practice based on his ideas of field and habitus (Singh, 2002). As with Bourdieu, the fields of the pedagogic device represent the social spaces in which agents vie for *resources* which in turn are used to determine the rules of the pedagogic device. In a sense, these rules represent normative distinctions pertaining to what knowledge is useful for members of society. As with Bourdieu, resources, or capital can take different forms depending on the field and the nature of the competition. The most suitable form of resources needed for an agent to achieve their desired result often depends on the field and the agent's motivations, ideologies, and aims. These aspects of an agent are informed by previous experiences and make up Bourdieu's concepts of *habitus* or *tastes.*

Bourdieu's focus on systems of power makes applying his tools in curriculum development in the context of this study an imperfect fit. While power is definitely a factor in determining what aspects of new research become secondary science curricula and how that process occurs, analyzing participant data for just that concept may result in missing additional factors that could be contributing to the process of curriculum development. Bernstein's Pedagogic Device offers a better process for examining curriculum development processes in real time by defining the process into Production, Recontextualisation, and Reproduction stages, each representing specific processes, considerations, and products. This provides an analytical lens to view, organize, and analyze data surrounding curriculum development processes in addition to outlining the practical decisions made during these processes. As each stage and its respective set of "rules" can be broken down into key questions, this creates very specific lenses through which one can view the collected data throughout the multiple processes of curriculum development in addition to the decision-making involved.

This does not mean that Bourdieu's concepts of habitus or his similar ideas of field and capital have no place in this study. While the pedagogic device is utilized as the theoretical lens for analyzing the 2011 Curriculum Revision processes which led to the introduction of genomics knowledge into the National Curriculum's Science PoS, both Bourdieu and Curriculum Theory have influenced some aspects of the study. Bourdieu's concepts of habitus and field help to provide a lens for viewing the motivations of the many agents that contribute to curriculum development processes. Curriculum Theory is drawn upon when considering the findings of the study. As stated previously, while curriculum theory and the concepts of habitus and field inform this study, Bernstein's Pedagogic Device represents the theoretical lens utilized for this study. As the research questions of the study focus on a particular instance of curriculum development process as opposed to a product as identified by previously presented literature, this was a proper utilization of the theory.

### 5.5 The Recontextualisation of Genomics and the Pedagogic Device

The pedagogic device can be used as a means for exploring the agents and competitions that specifically established genomics as suitable for secondary students and, by extension, suitable for the general public. The introduction of genomics knowledge into the National Curriculum can be seen as a desire to transform some aspects of genomics from esoteric knowledge used by researchers to mundane knowledge meant for more widespread understanding in the public. We can establish this was the case as specific text within the 2014 National Curriculum's Science PoS does contain references to both the human genome and the impact of genomics study (DfE, 2014). The pedagogic device offers a unique approach to exploring the how genomics came to be introduced into the National Curriculum. This theoretical approach can be utilized in both the collecting and analysis of data from both participants and documentation. Below is a visual representation of the Pedagogic Device:

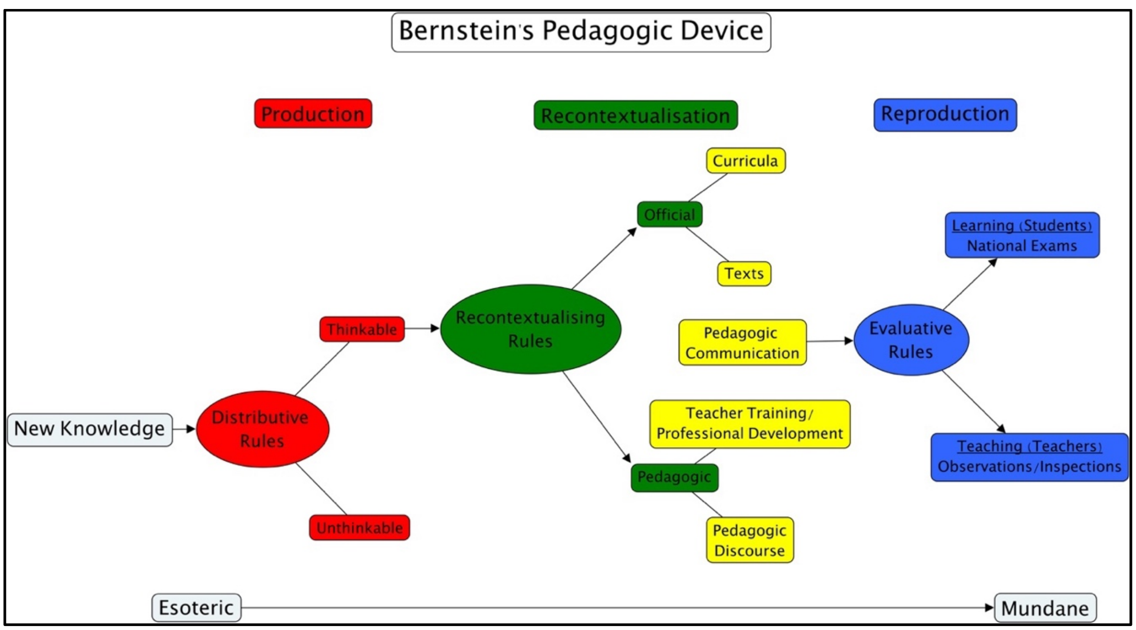


**Figure 5.1 Bernstein's Pedagogic Device** This outline of the pedagogic device establishes the hierarchal movement of knowledge through the fields of Production, Recontextualisation, and Reproduction.

Based on Singh (2002), and Wright and Froehlich (2009), Figure 5.1 outlines the hierarchical nature of the device as knowledge developed in the field of production must proceed to the field of recontextualisation before the field of reproduction. Figure 5.1 also outlines how the rules of the pedagogic device establish what can be transferred to subsequent fields. Determination of the distributive rules outlines what aspects of knowledge will go to whom, delineating what knowledge is meant for inclusion in school teaching from that which is not. Establishment of the recontextualising rules determines how knowledge from the field of production deemed suitable for school teaching is meant to be converted into different forms of pedagogic communication, either through the ORF, which converts the knowledge into official documents such as the curricula upon which textbooks are created, or the PRF, which establishes teacher preparation, training, and discourse. These forms of pedagogic communication affect the field of reproduction where the evaluative rules determine what constitutes suitable teaching of the newly recontextualised pedagogic communication and the criteria to determine if proper understanding has been achieved.

Employing Bernstein's concepts of the production, recontextualising, and reproduction fields in this way to organize agents and interactions is in alignment with previous research. Wright and Froehlich (2009, 2012) employed this process in exploring music practices in the United Kingdom and the United States. Bertram (2012, 2020) has also used the pedagogic device in this manner to study curriculum reform and its effect on history education in South Africa. In each study, participant data and documentation were used to outline the interactions of various agents to delineate spaces of competition to draw conclusions about the processes that determine what is taught in schools and the effects they have on social knowledge. As the goal of the study is examine the processes that saw genomics knowledge introduced into the National Curriculum Science PoS, utilizing these approaches can illuminate the specific process which were at play in this knowledge transformation.

## 5.6 Summary

In this chapter, I have outlined the ways Curriculum Theory, Bourdieu, and Bernstein have been used to study curriculum development as a process for affecting culture and socialization. All three have been used in the past to study how knowledge becomes what is taught in school. Bernstein's Pedgaogic Device provides the theoretical lens which allows me to answer my research questions which focus on the process of how genomics came to be introduced into the National Curriculum for England's Science PoS (DfE, 2014). While the pedagogic device is the theoretical lens applied throughout the study, Curriculum Theory informs the study and findings drawn from analysis utilizing the pedagogic device and Bordieu's concepts of Field and Habitus support identification of agents and their motivations in order to apply the pedagogic device to the data.  In the next chapter, I will outline how participants were chosen, data collected, and analysis carried out.

# Chapter 6: Methodology and Methods

As the research questions of the study focus on genomics and its introduction into the National Curriculum and what this may reveal about the processes that transform new scientific knowledge into science curricula and lessons, it was important to develop a theoretical and methodological approach that allowed for the collection and analysis of data from a diverse group of participants with varying professional backgrounds and experience within the case. As shown throughout the review of the literature, there were likely to be some social, political, and cultural factors at play and a diverse participant pool would help to explore these factors from numerous perspectives. In this chapter, I will outline the methodological approaches chosen to investigate this case as well as the methods involved. I will begin by giving a brief overview of the methodology employed.

## 6.1 Overview of the Methodology

A case study approach was chosen as a means of examining the research questions. As the goal of the study is to explore the processes that transform newly emerging science knowledge into school curricula and lessons through the examination of the introduction of genomics into the National Curriculum, any methodology surrounding the study needed to be suitable for obtaining and analyzing data from participants from diverse backgrounds and various documents. A case study approach allows for interviewing individuals with a wide range of experiences in addition to examining documents and other resources (Lapoule & Lynch, 2018; Yin, 2003). The case study approach also allows for the exploration of the research questions through the study of a specific case with specific boundaries so that examination of the data under the consideration of proper analytical tools can inform similar cases.

As the case involves looking at the specific instance of the introduction of genomics, participants with experience in the development of science curricula and science teaching materials were sought as a basis for collecting data. While the study did begin with looking at the specific process of curriculum revision initiated by the coalition government between the Conservatives and Liberal Democrats in 2011, it became apparent that there were many forces at play prior to that particular revision that did have some impact which required exploring. As this was the case, the participant pool contains individuals with experience in directly transforming genomics knowledge into secondary science lessons through professional development in addition to individuals who experienced the 2010-2013 Revision to the National Curriculum. This helped in developing a more complete timeline and picture of not only the 2010-2013 Revision which resulted in the 2014 National Curriculum's Science PoS (DfE, 2014), but also the efforts that proceeded it.

Data were collected from participants through semi-structured interviews. This approach allowed for each participant to describe the diversity of their experience within the scope of the case. Data was also sought from documentation when recommended by participants. This helped to add context to points coming out of the data, contributing to the narrative that developed. Analysis of data was done using multiple rounds coding based on criteria such as the time period referenced (prior to or during the 2010-2013 Revision), processes discussed (transformation of genomics discourse or knowledge), and several other details. Analysis included both inductive and deductive coding processes and was carried out using Bernstein's Pedagogic Device as a theoretical lens. This process was used to illuminate themes and develop the findings and conclusions of the study. The following sections examine each of these aspects in detail.

## 6.2 The Pedagogic Device and Genomics Knowledge

Central to the case of genomics in secondary schools is the overlapping interactions as genomics knowledge is determined appropriate for secondary students and converted from research knowledge to pedagogic communication meant to be explored in secondary science courses. Of great importance to the study of the processes that saw genomics introduced into the National Curriculum of England is the interactions of players or agents within fields as well as between fields. The pedagogic device helps to provide a lens through which data surrounding the case of genomics in schools can be accumulated, organized, and analyzed to determine the players, agents, institutions, and circumstances at play as well as what can be revealed about the nature of curriculum development and its influence on classroom instruction or vice versa.

The pedagogic device has been used to explore curriculum development both recently and in the past. Bertram (2012) has written about History Curriculum reform in various countries using the pedagogic device as a framing device, emphasizing the recontextualising of current findings in History into the curriculum. Using history curriculum documents, Bertram sought to investigate what these documents revealed about the progression of historical knowledge in South Africa, Kenya, Singapore, and Canada, finding that a memory history approach, one that promotes knowledge of national history and national values in the interests of preserving collective memory and fostering national identity, informs the Kenyan curriculum while the South African, Singaporean, and Canadian models favored a disciplinary memory approach, one that emphasizes learning to think historically using specific disciplinary processes. Further study established a link between approach and the recontextualising principles guiding the process.

Wright and Froelich (2012) have also written about the pedagogic device and the transference of musical knowledge into classroom discourse in the United States. Using the pedagogic device as a framework, Wright and Froelich investigated how gaps in the recontextualisation of musical knowledge allow for some degree of teacher autonomy by leaving a space in pedagogic communication for teachers to insert their own priorities of experience into the curriculum. This in turn leads to teacher-pupil interactions that establish new forms of knowledge reproduction.

Mathou (2018) writes about the mid-level actors involved in the process. Conducting interviews with individuals associated with three mid-level authorities, individuals situated between centralized government (the macro level) and teachers and schools (the micro level), Mathou sought to examine the work of pedagogic advisors and inspectors responsible for the professional development and support of secondary teachers in France and Canada. Drawing on comparative analysis, Mathou was able to specifically identify forms of recontextualisation linked to knowledge-based experience while also highlighting a deficiency in the literature exploring the role of mid-level agents, often referred to as regulatory agents, on the field of recontextualisation.

Although these particular studies consider different aspects of the pedagogic device and recontextualisation, each mentions a shortage of research that looks at the actors or players involved, specifically those people who contribute to the processes of the PRF outside the traditional roles of universities, classroom teachers, and other players of this particular field. The current study seeks to determine what the processes that led to the introduction of genomics into the English National Curriculum can reveal about the processes that transform newly developed scientific knowledge into secondary science curricula and lessons.

## 6.3 Methods

As the work of Bernstein makes up the theoretical and methodological underpinnings to this study, the specific method for the collection and analysis of data would need to complement this approach. The study required the need to obtain data from a wide range of participants, each with different backgrounds and experiences. This necessitated an adaptable method which could facilitate multiple participants with a wide range of experiences. In this section, I will outline the methods employed, their appropriateness for this study, and their limitations.

### 6.3.1 The Case Study Approach

The case study approach has been used in educational research to study a wide variety of concepts (Aiello-Nicosia & Sperandeo-Mineo, 2000; Aubusson, 2002;

Cosgrove & Schaverien, 1996; Karvánková & Popjaková, 2018). It has been employed to study topics as diverse as the efficiency of technology use in classrooms and the cost-benefits of implementation of educational programs. The appeal of this approach lies in its diversity. Case study can be used to examine a large number of phenomena while employing several methods of data collection. This versatility is key in understanding how case study has become so influential both in educational research methodologies and teaching as a process for learning (Lapoule & Lynch, 2018; McMahon, 1982; Rippin et al., 2002).

The term case study can be broadly defined. It is widely accepted that a case study approach seeks to add in-depth exploration and insight into a particular phenomenon (Ritchie et al., 2013). Merriam (1998) referred to the case study as a way to gain understanding of a situation while Stake (1995) believed that the strengths of the case study approach lay within the researcher's role as interpreter, using their own experiences and knowledge to explore a particular phenomenon highlighting the opportunity for perspectives when examining a phenomenon. Examining a phenomenon using the case study approach can be done using either quantitative or qualitative methods, often both. The method of data collection employed is dependent on the case.

At the core of the case study is the case. A case can be difficult to define. The definition is often dependent on the phenomenon being studied. In education, this can come in a range of differing forms. Merriam (1998) defines the case as being a unit, entity, or phenomenon with defined boundaries the researcher can demarcate. This definition encompasses a wide number of subjects that could be of interest to the investigator as well as a large number of methods to gather data. Miles and Huberman take a similar view referring to a case as a phenomenon of some sort occurring in a bounded context (Miles & Huberman, 1994). Stake (1995) also has a similar view on the difficult to define concept of "case", stating:

> The case could be a child. It could be a classroom of children or a particular mobilization of professionals to study a childhood condition. The case is one among others. In any given study we concentrate on the one. The time we spend concentrating may be one day or a year, but while we so concentrate we are engaged in case study. (p. 2)

Although all the above commentators note the wide and varying nature of the case study approach, they each place emphasis on studying the case in a very particular context. While the method of data collection can vary from case to case, what is important is that the data allows the researcher to examine the particular case within boundaries that allow for a specific context. Understanding the context of the case can give great insight in the "why" and "how" of the phenomenon studied.

The use of the case study approach can also be seen as a good way of studying the varying roles of individuals in policy creation and implementation. Braun et al. (2010) employed a case study approach when studying the policy enactment environments of secondary schools in the United Kingdom. Using semi-structured interviews with various policy actors both within and connected with the schools, the researchers sought to obtain some insight into policy environments created at the school level and how the actors involved perceived the creation and implementation of such endeavors. Their goal was to explore how schools make careful decisions about policy priorities and to examine the ranges of policies at play. They used four secondary schools situated in the southeast of England as the basis for their case and included a wide range of individuals in their interviews. Using a case study approach, the authors were able to determine how these individual schools in England went about setting their policies and how they attempted to reconcile the differences that sometimes arose between local school policies and national policies.

### 6.3.2 The case of genomics in schools and the curriculum

The case study approach represents a good pathway to study how genomics came to be introduced into the National Curriculum's Science PoS (DfE, 2014) and secondary science classrooms in England for a number of reasons. It offers the opportunity to consider the subject from the viewpoints of multiple agents. The introduction of genomics into biology courses was the result of a number of different actors in various fields, some of which are included under the umbrella of education, such as curriculum development, science education policy creation and implementation, and classroom practice. Other fields outside of education also made contributions to its introduction. Actors in the fields of medicine, genetics research, and politics also played important roles. Looking at the introduction of genomics as a case study could yield very important insights into a variety of subjects involving the sometimes-overlapping fields of science education, medical science, and curriculum development. Examining this particular instance of curriculum development as a case specifically allows for the exploration of the multiple stakeholders involved in addition to their individual motivations and influences on the process. Highlighting these aspects can help to ascertain how different parties affect both the processes that determine what elements of new knowledge become what is taught and the influences behind these processes.

The current case focuses on studying how genomics came to be introduced into the National Curriculum of England. While initially this seems like a broad topic, the case does have distinct boundaries. As mentioned previously, the National Curriculum's Science PoSs (DfE, 2013 & 2014) contains the first direct mentions of genomics within Key Stages 3 and 4. Since this curriculum was the result of revision processes initiated in 2011 by the Conservative Government in coalition with the Liberal Democrats, that process formed the preliminary point of examination. Through collection of participant data and documentation it became apparent that aspects of the case preceded the 2010-2013 Revision processes, so the case extended further into the past to 2002 and the publishing of the genetics white paper *Our Inheritance, Our Future* which established the Genetics Knowledge Parks, organizations designed as a cooperative effort between government departments, private research organizations, universities, and others in developing ways to utilize newly emerging knowledge in genomics research. These organizations were developed as the Human Genome Project neared it completion and one in particular, the Northwest Genetics Knowledge Park (Nowgen), can be seen directly linked to the recontextualisation of genomics knowledge towards secondary science courses. As such, it is during this period of 2002 to 2016 that the current case focuses on.

The case study approach allows for the exploration of the research questions through the collection and analysis of data from both multiple participants and documentation. The introduction of genomics knowledge into the National Curriculum involved the interactions of many different actors in various fields. Exploration of documentation from the time helped to provide political, historical, and social context while interview data obtained from the participants helped to explore the multiple viewpoints and motivations of the principal actors involved in addition to some insights into how they affected the movement of genomics knowledge towards secondary science courses. Combining these elements into a case allows for a thorough investigation into each of these elements and the role they played in seeing genomics introduced into the National Curriculum's Science PoSs (DfE, 2013 & 2014).

### 6.3.3 Identifying and recruiting participants

The case focuses on the development of the National Curriculum's Science PoS (DfE, 2013 & 2014), as it represents the first time specific elements of genomics knowledge make an appearance into the National Curriculum for England. Initial participant recruitment centered on individuals with firsthand experience within that event. Many of the participants in this study were direct contributors to that process of revision and speak to their experiences. As it became more apparent that examining the processes that saw genomics introduced into the National Curriculum's Science PoS (DfE, 2013 & 2014) could be linked to additional factors such as the development of the Genetics Knowledge Parks and the Nowgen Schools Genomics Programme, the recruitment of participants expanded to include individuals with experience in these elements also. As a result, many participants in the study have direct experience working or collaborating with Nowgen and their Schools Genomics Programme. There was also an effort to obtain data from an individual familiar with teaching the previous curriculum but not necessarily developing it. This was done in an attempt to get a more ground level understanding of how these processes of curriculum development affect decision-making by teachers at the classroom level. The result is a participant pool with a diversity of professional experience but a direct expertise in the case at hand.

Securing these participants required a method that would allow for the collection of data through a means that gives participants of varying backgrounds an ability to expound on their experiences without being limited by specific questions. Snowball sampling, a recruiting technique in which participants are asked to assist the researcher in identifying other participants, was employed as a method for gathering participants. Lee (1993) states the use of Snowball Sampling builds security as the participants are known and trusted members are added to the sample. He does caution against bias, as participants of shared phenomena are likely to have close relationships, the potential for a skewed sample of participants increases. To combat this occurrence many viewpoints were sought during participant selection to help to prevent bias. The majority of the participants of the study either directly participated in the 2010-2013 Revision process or the development of genomics-based lessons and professional development for secondary science teachers. Only one participant did not fit these criteria. This was done purposely to collect the viewpoint of an individual with experience teaching the curriculum but not developing it. The first participant came as a recommendation from my supervisor, as he had some familiarity with the developing case. Others came based on the recommendations of preceding participants. This process allowed for the building of a participant pool with varying backgrounds, but also the overlapping experience associated with the case. As participants were recommended, they were first contacted by email to gauge their interest in participating and interviews were set up accordingly.

Ginny W was the first participant interviewed. With a background working in science curriculum development with organizations such as the Nuffield Institute, Ginny W came recommended by my supervisor as she was a direct participant of the 2011 Science National Curriculum Working Group, the group of expert science educators and professionals tasked by the Conservative Government with revising the National Curriculum in 2011. Katie B is a former genomics researcher who decided to transition into science education. As she made this transition, she would work in collaboration with the Genetics Knowledge Parks on matters such as public engagement which would include developing lessons for secondary science teachers to engage their students with new ideas emerging from genomics research.

Dean T has an extensive background working in science education research and academia. He has been a participant in the development and revision of many science curricula including the development of the National Curriculum for England for both 2007 and 2013/2014 PoSs for Science. This experience gives Dean T particular expertise in discussing the processes in terms of significant similarities and differences. Susan B has extensive experience as a science textbook writer and has also been a participant on numerous curriculum revision processes including the 2010-2013 Revision.

Both Cedric D and Hannah brought a wealth of experience working with science research organizations and their educational outreach programs. Through these connections both would play a pivotal role in working with Nowgen and their Schools Genomics Programme which sought partnerships with other organizations.

Oliver W also has a background in project management and has worked for several organizations in science education outreach. While contributing to Nowgen and the Schools Genomics Program, Oliver W was simultaneously a participant of the 2010-2013 Revision process.

Marietta E is a secondary science teacher with over a decade of experience teaching biology across GCSE and A-Level courses. She is the only participant not affiliated with developing curriculum or genomics-specific material at a national level. Her expertise as an individual with experience teaching the curriculum was sought out as a means of examining how national processes of curriculum development affect teaching at the classroom level. Table 6.1 outlines each participant and their recommendations:

**Table 6.1. Participant Recommendations**

| Participant | Recommended by | Experience with the Case | Recommended |
|---|---|---|---|
| Ginny W | My supervisor | Member of the 2011 Science National Curriculum Working Party | Dean T, Cedric D, Oliver W, Katie B, Susan B |
| Katie B | Ginny W, My supervisor | Worked as a genetics/genomics researcher prior to developing Genomics-based lessons for secondary science students | Dean T, Cedric D |
| Dean T | Ginny W, Susan B | Member of the 2011 Science National Curriculum Working Party | Susan B |
| Cedric D | Ginny W, Katie B | Involved in the Nowgen Schools Genomics Programme | Hannah A, Oliver W, Susan B |
| Hannah A | Cedric D, Katie B | Involved in the Nowgen Schools Genomics Programme | Oliver W |
| Susan B | Ginny W, Dean T, Cedric D | Member of the 2011 Science National Curriculum Working Party | Oliver W |
| Oliver W | Ginny W, Cedric D, Hannah H, Susan B | Member of the 2011 Science National Curriculum Working Party and involved in the Nowgen Schools Genomics Programme | Susan B, Cedric D |
| Marietta E | My supervisor | GCSE and A Level Biology teacher with some experience teaching both students from the previous curriculum and students under the revised curriculum | None |

As explained, each participant brings both expertise and experience to the current case. Ginny W, Dean T, and Susan B were all contributors to the 2010-2013 Revision processes that saw genomics knowledge introduced into the 2013/2014 National Curriculum's Science PoS (DfE, 2013 & 2014) for England. In addition to this expertise, they each have also contributed to the development of various science curricula in the past. Oliver W also played a role during that revision and, along with Cedric D and Hannah A, had extensive experience with transforming genomics knowledge into secondary school lessons through their work with the Nowgen School Genomics Programme. Given Nowgen's role in the raising awareness of knowledge emerging from genomics research, having participants who can speak to their experiences within the organization provides a very useful voice in examining the case. Katie B also brought a wealth of expertise to the case as an individual with experience in genomics research, science education, and developing genomics-based lessons and Marietta E's inclusion helped to provide the voice of someone familiar with teaching the products of numerous curriculum development processes. In all, it can be said that the pool of participants offers not only expertise in the case being studied, but also diversity in experience making the data collected very strong. While the sample does exhibit the diversity of expertise needed to examine the research questions, it does have its limitations. Attempts were made to reach out to civil servants working within the Department for Education during the times of the case boundaries but were unsuccessful as some participants felt it inappropriate to put me in contact with civil servants and recommended contacts declined or failed to respond.

Ethics considerations were taken into account prior to the start of the study. All participants were assured of the ethical nature of the study and anonymity upon agreement of participation. Each signed a consent form that outlined the purpose of the study in addition to benefits, potential risks or discomforts, measure of confidentiality taken, and assurances of voluntary participation (Appendix A). Strict anonymity was maintained by assigning each participant an alias with the actual names kept in an encrypted document under password protection.

### 6.3.4 Data Collection

All participants underwent a semi-structured interview as a means of collecting data. Each participant had experience within the current case and some degree of diversity in their professional background in science education. This lack of homogeneity among participants required an interview protocol that allowed participants the freedom to expound on their experiences in with genomics and the National Curriculum. To establish a protocol, all interviews began with an introduction and the same question: "I am studying how genomics came to be introduced into the National Curriculum for England. What can you tell me about that?" This question was followed by a continued process of open-ended questioning and clarification as the participant described their experiences within the case. Each interview was recorded and transcribed for analysis. This protocol can be found in Appendix B.

The use of semi-structured interviews was a deliberate choice because of the diversity of experience within the participant pool. The goal was to explore the experiences of the participants within the case and while structured or focus group interviewing could have been employed, semi-structured interviews provided an opportunity for each participant to discuss their experience within case while also expanding to topics adjacent to it through the use of open ended questioning as opposed to specific questioning other than the interview prompt (Barriball & While, 1994; Moser & Korstjens, 2018; Robinson, 2014). Interviewing participants individually as opposed to focus group interviewing made sure each participant was able to give their account uninhibited by others.

As with any study, this approach has its drawbacks. While the data can be perceived as representing personally objective, accurate accounts of what is being examined, there is the possibility of personal interpretation skewing what they say (Silverman, 2015). This can make achieving reliability a difficult prospect. To assure against misinterpretation of collected data, summary emails were sent to participants after each interview. The case study approach also allows for the examination of documentation to help bring additional context to the collected data adding to its reliability (Crowe et al., 2011).

Documentation was collected through recommendation by participants and through research as a means of further contextualizing collected data. For example, many participants made reference to the 2003 genetics whitepaper titled *Our Inheritance, Our Future*. As mentioned previously, this white paper would establish a number of partnerships between government bodies and other organizations with the aim of exploring the ways new discoveries in genetics and genomics may impact British life. As several participants referenced the paper it was used as a means of both exploring the case and triangulating some aspects of participant reporting. Documents from government departments such as the Department of Health (DoH), the Department for Education (DfE), and Nowgen itself were utilized in this fashion so as to strengthen the data collected.

As stated previously, while the study succeeded in securing participants from varying backgrounds with significant experience within the case in question, attempts at data collection from individuals working within the Civil Service were unsuccessful. In lieu of this, documentation from the Department of Health and the Department for

Education were used to gain some insight into the Government's stances. This combination of both participant and documentation is commonly used to develop a case (Crowe et al., 2011; Lapoule & Lynch, 2018). Table 6.2 outlines the documentation used in this study.

**Table 6.2 Documentation Utilized for the Study**

| Documents | Rationale |
|---|---|
| **Department of Health (DoH)** | |
| • *Our Inheritance, Our Future* (2003)<br>• *Our Inheritance, Our Future Progress Summary* (2008)<br>• *Government Response to the House of Lords Science and Technology Committee into Genomic Medicine* (2009) | These documents help to outline government strategies and partnerships that would be utilized introducing newly emerging genetics/genomics knowledge to the public and social infrastructures such as healthcare and professional training for healthcare workers. They establish the Genetics Knowledge Parks and also outline the role that the newly emerging knowledge was meant to take in higher education. |
| **Northwest Genetics Knowledge Park (Nowgen)** | |
| • *Genomics in Schools: An Interim Report from the Nowgen Schools Genomics Programme* (2011)<br>• *A Modern Education in School Science: A Manifesto for Change* (2012) | Established by the Department of Health, Nowgen was tasked with increasing public awareness of genomics knowledge. Through establishing partnerships with several organizations, they would develop the Nowgen Schools Genomic Programme (NSGP) which would help to provide secondary science teachers with lessons and classroom experiences centered on introducing the students to genomics knowledge. These documents help to outline their organizational goals, partnerships, and strategies. |
| **The Department for Education (DfE)** | |
| Review of the National Curriculum in England:<br>• *Summary Report of the Call for Evidence* (2011)<br>• *The Framework of the National Curriculum: A Report by the Expert Panel for the National Curriculum Review* (2011)<br>• *Reforming the National Curriculum in England: Summary Report of the July to August 2013 Consultation on the Programmes of Study and Attainment Targets from September 2014* (2013)<br><br>National Curriculum in England:<br>• *Science Programmes of Study Key Stages 1 and 2* (2013)<br>• *Science Programmes of Study Key Stages 3* (2013)<br>• *Science Programmes of Study Key Stages 4* (2014) | These documents help to outline the processes undertaken by the Department for Education as they sought to review and revise the National Curriculum for England. They help to give some insight into the Government's viewpoint on the process that saw genomics introduced into the National Curriculum. As the study was unable to secure interviews from those working in the civil service at the time, these documents helped to gain some insight into what was happening during consultations and other parts of the process. |

### 6.3.5 Processes of Analysis

All collected data was analyzed through both inductive and deductive coding processes. Participant data was coded using thematic analysis and documentation using discourse analysis. Braun and Clark's (2006) method of thematic analysis was used as a basis for coding participant data. As the participants provided differing perspectives and experiences in exploring how genomics came to be introduced into secondary science courses, it was important to select a method that allowed for a process of coding the data in search of patterns and recurring themes as they arise from the data. This method was chosen due to its flexibility in identifying patterns both within and across data (Clarke & Braun, 2014). Braun and Clark's method also allows for both inductive and deductive coding processes which would be helpful in analyzing the data. While analysis did emphasize the participants' direct experiences within the case, there were times their perspective and perception of other agents and events both within and adjacent to the case were sought out to provide valuable insight and clarity in exploring discrepancies.

When needed, Jones's (2005) method of discourse analysis was employed to investigate relevant texts recommended by participants or sought out to deepen developing narratives. Jones's method specifically allows for the analysis of how human beings use language to communicate aspects of culture and social discourse. Viewing the events that saw genomics introduced into secondary science courses through Bernstein's pedagogic device invites critiques on how concepts such as power and cultural tastes affect the production of pedagogic communication. Jones's processes of looking at how humans communicate across social and cultural lines was especially useful in examining texts such as curriculum documents, white papers, and organization manifestos.

Both of these processes of analysis helped organize the collected data. This organization helped to determine recurring themes and points of both concurrence and division amongst participant data and documentation. The highlighting of these themes led to the development of conclusions and results based upon the rich descriptions gained from analysis of data collected from participants with diverse backgrounds experiencing the same event from different perspectives.

There are drawbacks to analyzing data in this manner. As with any coding process, the development and implementation of a coding scheme are privy to subjective interpretation and perhaps a lack of standardization leading to subjective bias (Aronson, 1995; Clarke & Braun, 2013). While these drawbacks can be present, the current study did employ multiple sources of data and information in an effort to paint a clear picture of the case. The participant pool was also kept at a size to maximize diversity of experience within the case but not too big as to make coding the data overwhelming, possibly leading to data sets too complex for the scheme of analysis. The result is a process in which the participant recruitment, data collection, and data analysis are in alignment in examining the research questions.

### 6.3.6 Methods of Coding the Collected Data

The collected data would undergo several rounds of coding in attempts to explore the processes that saw genomics added to secondary science courses. These rounds would focus on discovering aspects of the case such as the individuals and organizations involved, the fields of play in which these organizations compete to achieve their outcomes, and a specific timeline of events. It is here that both Braun and Clark's (2006) thematic analysis and Jones's (2005) methodology of discourse analysis based on Hymes's (1974) SPEAKING model provided processes that focused coding the data.

For thematic analysis of participant data and documentation the following method was employed:

1. *Familiarizing yourself with your data*
2. *Generating initial codes*
3. *Searching for themes*
4. *Reviewing themes*
5. *Defining and naming themes*
6. *Producing the report*

For discourse analysis of documentation, Jones's method based on Hymes's SPEAKING protocols was employed to establish context. This meant viewing the text of documentation for the following (Ray et al., 2011):

*Setting* - The time, place, and environment of the text

*Participants* – Who (speaker and audience) are involved in the text

*Ends* – The purpose and goals of the text

*Act sequence* – The order of events of the text

*Key* – The tone and manor of the text

*Instrumentalities* – The form and style of the text

*Norms* – Define what is socially acceptable in the text

*Genre* – Type of text/speech being given

The coding process was carried out in different stages. The initial process of coding was inductive. The literature review revealed the potential influence of social and cultural factors in past curriculum development studies, this was carried out to gain some initial insights into what each participant was revealing about the case with no prior codes in mind. This helped to outline various experiences and viewpoints as well as some of the aforementioned *Participant* and *Process* factors that affect curriculum outlined previously (2.4).

From there, coding was focused on viewing the data through the prism of the pedagogic device. These deductive processes were centered on coding the data based on the three fields of the pedagogic device (Production, Recontextualisation, and Reproduction), the agents that occupy each field, and their motivations. This coding would be done in attempts outline what the data reveals about the distributive, recontextualising, and evaluative rules that help to reveal how knowledge theoretically progresses towards new discourse. In the following sections, I will explain how these methods of coding were used to analyze the processes that led to the introduction of genomics into the National Curriculum.

#### *6.3.6.1 Initial Coding*

Each interview was carried out in the same fashion. After beginning the recording and some brief introductions, the initial question outlined the focus of the study and asked what the participant could reveal about their experiences with the topic. From there, open ended questions were used to obtain further insight and clarify any potential misconceptions. The recording was then transcribed for processes of coding and analysis.

Initial coding was carried out through an inductive process. This was done without previously established codes to gain an initial understanding of what each participant was saying about the case. Each line of dialogue was isolated, entered into a schema, and coded for a broad topic (Construct) and more specific codes within that topic. The schema also contained a section for Comments to record any inferences or connections to other data. This also helped to organize and keep track of the topics discussed for further analysis later. An excerpt from the initial coding of Ginny W's data can be found below:

**Table 6.3. Initial Coding for Ginny W**

| Statement | Construct | Codes | Notes |
|---|---|---|---|
| *Even so there was a big debate about whether what you should need to know by the age of 16, which is the national curriculum, should you start with Mendelian genetics and get people to understand the mechanism of inheritance and then at advance level go on to talk about the more recent advances and the way we look at genomics, population studies or should you do it the other way around* | **Discussion amongst members of the 2011 National Curriculum Working Party** | *Scope and sequencing of Genetics lessons<br><br>*Where does Modern Genetics belong within the curriculum? Who should be the target audience? | |
| We had arguments on both sides because you could start teaching genetics from looking at a population and the proportion of people with different attributes and so on but it's almost impossible to get fundamental changes | **Discussion amongst members of the 2011 National Curriculum Working Party** | *Scope and Sequencing<br><br>*Frustration with the difficulty of changing the curriculum | The participant speaks as if there were only two solutions. I wonder if there were more options considered…<br><br>Curricular Inertia rears its head… |

This process of coding was instrumental in organizing the data to be viewed through the theoretical lens of the Pedagogic Device. While the pedagogic device does delineate the processes for selecting and transforming knowledge for other discourses, in this case from a research discourse to one of secondary science curricula, into three fields, the process for applying these fields in any specific case can seem subjective. By employing an inductive coding process at the beginning, I was able to outline what the participant data was saying in general to develop an idea of how deductive coding based on the theoretical lens could be applied. For example, above Ginny W speaks about discussions regarding whether normal level science students should be taught about modern advancements in genomics research such as population studies or whether this information should be omitted but left for students in more advanced science courses. Viewed through the lens of the pedagogic device this can be seen as a competition regarding the target audience of new discourse which often occurs during the Production field. As such, this was one of many phrases used to develop deductive codes for analyzing participant data regarding the field of knowledge production. This process also helped to outline some initial themes to the data. To exemplify this process, Ginny W's entire schema can be found in Appendix C.

During this initial inductive phase of coding three themes stood out. First, there was the theme of *Relevance*. Much of the discussion surrounding the discourse on genomics knowledge centered on whether it was relevant for secondary students. There are numerous utterances from participants focusing on what genomics knowledge represents to secondary students as current learners and potential consumers of genetic medicine. The consideration of these elements represent discourse on the idea that genomics knowledge was more relevant to current learners on the precipice of joining society than the genetics knowledge secondary students were currently receiving.

The second theme that arose from initial explorations of data was one of *Substance*. If genomics knowledge was of greater relevance to current secondary learners, what aspects of that knowledge do learners need to be familiar with? Who should be tasked with making this decision and what are the processes involved? Preliminary examination of the data revealed two pathways in which questions about what aspects of genomics knowledge students need to be aware of were considered and how it should be altered for secondary science students. In both pathways discourse often focused on what to introduce students to and how current genetics teaching could potentially be altered to fit cultural and societal dynamics. This led to the third theme.

The third theme arising from initial exploration of the data was Transformation. While early discussions centered on the relevance of genomics knowledge and what secondary students needed to be aware of, there were also numerous utterances about the processes which would transform genomics knowledge from a research discourse to one fit for secondary science students. With the themes of relevance, substance, and transformation highlighted, more coding would be needed to continue to explore the case, particularly through the lens of the pedagogic device. Using this initial process helped to start to develop some inductive coding to view the data in this light.

#### *6.3.6.2 Coding for Pedagogic Field Data*

As noted above, the Pedagogic Device considers the regulation of the production, transmission, and acquisition of the school curriculum through the interactions of players or agents in three distinct fields: Production, Recontextualisation, and Reproduction (Bernstein, 2004). For the sake of this work, the term *agents* will be used to describe the individuals, organizations, and collectives involved in the case. This use is consistent with previous utilizations of Bernstein's principles. Each field represents processes of decision-making regarding what knowledge is suitable for new audiences, how that knowledge is meant to be reconstructed for that new audience, and what will represent proper teaching practice and learning by that new audience.

In terms of the current case, coding the data in this manner helps to organize the decisions and processes that saw genomics introduced into specific phases. This helps to outline the agents involved in these phases while also delineating where they are having influence. While this does help organize the data, problems did arise with specifically delineating the influence of agents on one field from another as there is often overlap in the agents of each of the fields. The collection of both participant data and documentation did help to better delineate the fields as will be illustrated below.

Further processes of coding were undertaken to consider what the data revealed about other aspects of the case. Unlike the initial coding processes, coding for the fields of the pedagogic device was a deductive process as opposed to inductive. As the goal of this coding was to specifically look at the data through the lens of the pedagogic device, deductive codes based on each field were developed. A schema of analysis was devised using codes developed during the initial inductive coding processes. For example, during the initial inductive coding process many participants made reference to the potential for genomics testing to affect secondary student lives in the future. This argument of relevance can be seen as a representation of the Bernstein's field of Production as it focuses on the appropriateness of genomics knowledge for secondary students. Using this information as a basis for coding, each participant statement was classified as pertaining to the fields of Production, Recontextualisation, or Reproduction. Viewing the data in this method helped to organize those aspects for comparison that would be crucial to processes of analysis. As each participant brings their own experiences to the study, organizing the data in this manner helped to make it easier to compare and contrasts utterances across multiple sets of data when examining it through the lens of the pedagogic device. Table 6.4 lists the schema criteria for coding based on the fields:

**Table 6.4 General Criteria for Coding Participant Data**

| Field Code | General Criteria | Examples (references to) |
|---|---|---|
| Production | Data pertaining to genomics as research science and the determination of who would benefit from exposure to it | *Human Genome Project, Genome Wide Association Studies, DNA Sequencing Studies, Implications of Genomics Data for the Public, Public Engagement, School Outreach* |
| Recontextualisation | Data pertaining to the transformation of genomics knowledge from one discourse to another and into pedagogic communication | *Development of Genomics Public Engagement Materials, Genomics Professional Development for Secondary Teachers, Genomics Research in Education Policymaking* |
| Reproduction | Data pertaining to the teaching or assessment of individuals being asked to learn the newly recontextualised genomics knowledge | *GCSE and A-Level Exams, Classroom lessons, Decision making based on Genomics Information* |

The field of Recontextualisation was divided to illustrate its sub-fields.

**Table 6.5 General Criteria for Recontextualising Field Coding**

| Recontextualising Field Code | General Criteria | Examples (references to) |
|---|---|---|
| Official Recontextualising Field (ORF) | Recontextualising data pertaining to the use of local or national government policymaking bodies or pathways affiliated with government or local authorities in altering secondary science courses | *Revision of the National Curriculum in England, Revision of the Scottish National Curriculum, Science National Curriculum Working Group* |
| Pedagogic Recontextualising Field (PRF) | Recontextualising data pertaining to the altering of secondary science courses through university education departments, educational organizations, professional development, public engagement, etc.… | *Professional Development, Classroom Resources, Textbook Writing, Lab Experiences for Students* |

This process required breaking down each individual statement to explore what it may reveal about discussions regarding the development of genomics knowledge as research science, the determination of who was meant to receive said knowledge, how it was meant to be transformed for new discourse, and how it could be determined that said knowledge was learned. For example, when discussing the amount of influence wielded during the 2010-2013 Revision process, Oliver W reported:

> "We were trying to sort of get in touch with Department of Education and suddenly at some point that actually worked and we found ourselves being invited to some events at the Department of Education to talk about the new science curriculum, specifically biology curriculum."
>
> Oliver W

As Oliver W is referring to attempts to affect the 2010-2013 Revision of the National Curriculum, this particular statement was coded as ORF or Official Recontextualising Field. We see mentions of trying to affect the formal process of curriculum development carried out by the Government, distinguishing the data point from fields such as Production or Reproduction as the former deals with the direct production of knowledge at research centers and the latter pertains to the processes surrounding the teaching and assessment of previously recontextualised knowledge. Color coding of the data was also applied to help visually highlight each field for analysis. Table 6.6 outlines this schema analysis with the previous excerpt from Oliver W's data in addition to another utterance:

**Table 6.6 Excerpt from Oliver W Pedagogic Device Schema**

| **What did they say? (Utterance)** | **Field Represented** **Production** **Recontext (ORF,PRF)** **Reproduction** | **Notes** |
|---|---|---|
| *We were trying to sort of get in touch with Department of Education and suddenly at some point that actually worked and we found ourselves being invited to some events at the Department of Education to talk about the new science curriculum, specifically biology curriculum.* | Recontext ORF | Prior to the Revision the school genomics program provided by NOWGEN which prioritized creating both professional development and classroom experiences, here the focused is shifting from supporting individual teachers to include teaching activities regarding genomics to wanting to influence national policy to include genomics in the national curriculum |
| *For a short period of time there was the idea that the exam boards would bid to be sole provider of examinations for particular subjects, which is quite an interesting idea but they were all very anxious about that.* | Reproduction | The variability amongst exam boards made affecting widespread change difficult, it left the possibility of genomics being include/excluded in varying degrees in examination specifications. |

### *6.3.6.3 Coding to Identify the Agents*

Upon establishing Field Data, each transcription was coded for specific mentions of the agents involved in seeing genomics introduced into the National Curriculum. While the participants were asked about their specific experiences, there were numerous occasions in which they spoke about other parties that played key roles in the events that would eventually lead to the introduction of genomics knowledge into the National Curriculum for England's Science PoS (DfE, 2013 & 2014). Although participants often pointed to direct interactions with and amongst these bodies, to capture the full extent of the case, data regarding the perception of the participants about others and their motivations was also sought out when appropriate. To this extent, all specific utterances surrounding key agents were isolated and placed into a chart to ascertain what each statement reveals about the players involved in the case. Table 6.7 outlines the aspects of the data explored with these charts.

**Table 6.7 Heading for Agents Analysis**

| | |
|---|---|
| ***Reference Number*** | A selected number to organize and identify each statement |
| ***Utterance*** | The statement made by the participant |
| ***Agents Represented*** | The players of the case identified in the statement |
| ***Comments*** | What can be inferred from the statement |

Aspects surrounding concepts such as the individuals and organizations and their interactions with other agents were highlighted. Table 6.8 shows an excerpt from Cedric D's data:

**Table 6.8 Excerpt from Cedric D Agent Analysis**

| Reference Number | Utterance (What did they say?) | Agents | Notes (What can be inferred from what was said?) |
|---|---|---|---|
| CD10 | I think the reason for this included the fact, and it's more of a general criticism of the way in which curriculum development took place in science, a lot of the examiners and chief examiners had a huge amount of experience and were therefore quite old or many of them did it as a sideline as they came to the end of their teaching or academic careers that they were a long long way in many cases from the research that was emerging from the lab, that was one reason | Assessment examiners | He infers that although the changes could be made, doing so without also developing proper assessment and individuals who could interpret/grade the assessment would have been difficult |
| CD11 | Another reason was that there was a lot of change taking place in the educational system, still is, but there was at the time and there was a reluctance to impose new concepts on science teachers, new subject matters that they were unfamiliar with | Science teachers, Curriculum Developers (?) | He also infers that higher powers (who?) preferred not to add new concepts to the teachers' purview |

In statement CD10, the participant explicitly refers to the examiners, *"A lot of the examiners and chief examiners had a huge amount of experience and were therefore quite old…"* Here the participant explores the role of examiners and, as such, they are listed as an agent. Statement CD11 refers to two possible agents as the participant mentions a group of individuals reluctant to impose new concepts on working science teachers. As *science teachers* are specifically mentioned as a subject, they are listed under Agents. The general phrase, *Curriculum Developers (?)* is used to list the individual's reluctance to impose new concepts on teachers here with a (?) noting the slight ambiguity of the statement. Each analyzed statement was then used to identify the participant's perceived players in addition to how they observed the power structures involved during the curriculum development process.

Data from these charts was used to determine how each participant experienced the processes that that led to the addition of genomics to the National Curriculum and the power structures that drove them. They helped develop some semblance of hierarchy in terms of the agents involved as well as where they fit into the overall power structure of curriculum development according to the participant. As Bernstein's Pedagogic Device is often used as a means for examining power structures and their effects on the development of pedagogic discourse and communication, this was an appropriate way of determining and analyzing data (Lim, 2017; McCloat & Caraher, 2020; Singh, 2017)

#### 6.3.6.4 *Coding for Motivations*

As the Pedagogic Fields and Agents of the case were examined, it was also important to explore the potential motivations of these individuals and organizations. Power often plays a role in the determination of the curriculum. If the power structure of the case was to be determined, understanding the motivations of those agents involved would be integral to examining its effects on the processes that saw genomics entered into the National Curriculum for the first time. It was here that some aspects of Bourdieu's concepts of habitus helped to inform the coding process.

As mentioned previously, Bourdieu's concept of habitus refers to the subjective but not individual system of internalized conceptions and perceptions to members of the same group (Grenfell & Lebaron, 2014). These aspects of a group or organization ultimately inform decisions around aims, goals, and motivations, often referred to as "tastes". There are numerous other aspects to Bourdieu's concept of "tastes" but for the sake of the current case, exploring the elements of the data that reveal some aspects of aims and motivation for either championing or discouraging the introduction of genomics into the National Curriculum would help to better understand the power structure of the case and some of the alignment amongst agents participating on the field.

To that extent, some aspects Bourdieusian Analysis was also employed to examine the data for agent motivations. Incorporating aspects of the previously mentioned inductive and deductive methods of coding and Grenfell and Lebaron's (2014) method of coding for Bourdieusian concepts, each point of data was coded for Agents Mentioned/Inferred and Constructs of Tastes . Employing this method allowed for the highlighting of any aspects of the data across multiple interviews pertaining to why some organizations sought influence on the discussion surrounding genomics, what is taught in schools, and the curriculum. Coding for this process was more inductive than coding for the pedagogic fields or the agents which involved pre-developed codes or highlighting the mentions of organizations and individuals involved. This was due to not wanting to restrain the process with any preconceived notions towards agent motivation. Take the following example from Hannah A as she spoke about the alignment of Government and Nowgen:

***Table 6.9 Excerpt from the Analysis of Hannah A***

| Statement | Agents Mentioned or Inferred | Constructs of Tastes | Notes |
|---|---|---|---|
| *I understand it as if you're going to mainstream genomics, into the NHS it's obviously you need a workforce that is going to be comfortable with genomics and that includes existing workforces and perspective workforces and that's what the secondary education bit comes in in terms of prospective workforces.* | Government, Nowgen | Desire for increasing medical relevancy of genomics<br><br>Developing greater genomics knowledge in the current and potential workforce in the medical field | Medical Application has been mentioned by others as an impetus for expanding genomics knowledge amongst the public and school age children (Cedric D, Dean T, Katie B, and Oliver W) |

Here Hannah A's statement reflects her understanding of the decision to shift some emphasis of the spread of genomics knowledge in healthcare from engagement with the general public to secondary science courses. As the participant was speaking about the Government and Nowgen's alignment in view, both were listed as the Agents. The participant generally speaks of *"mainstreaming genomics into NHS"* which can be inferred as an aim of the aforementioned agents. The phrase *"it's obvious you need a workforce comfortable with genomics,"* gives indication about how a growing need for individuals with genomics knowledge could affect the future job prospects of current students seeking careers in the medical profession which is noted in the Constructs of Tastes portion. From there, comments were recorded about where this statement fits with other points of data such as participant transcripts or documents analyzed. Each transcript was coded in this way to begin searching for recurring ideas and broad themes amongst the participants.

Coding in this fashion helped to identify some aspects of each agent's motivation and aims regarding the teaching of genomics and its place in the curriculum. This is important to the case as it helps to outline varying alignments between agents seeking influence with the development of genomics in the curriculum and helps to develop a visualization of the power structures involved. From this coding process I was able to devise a clear picture of some aspects past views on genomics in schools. Through examination of participant data and documentation I was able to develop some insights into how those involved in the case viewed the role of science education and the processes responsible determining what aspects of developing knowledge are appropriate for secondary science courses.

There are some issues with this approach. As mentioned previously, the participants were asked to speak about their personal experiences with the case. To gain more insight into the case, there are times the participants were asked about their perceptions of events and motivations outside of their own experiences. To that degree, there is a certain amount of conjecture expected. When this occurred other documents and participant data were used to try to determine the actual nature of the case.

#### *6.3.6.5 Coding to Develop a Timeline*

After some discussion with my supervisors, another layer was added to the previously mentioned field schema to help orient the data based on time frame. A significant moment in the inclusion of genomics into the curriculum was the 2010-2013 Revision of the National Curriculum. This particular process of revision saw some formal genomics language entered into the biological sciences portion of the curriculum. To highlight portions of the data that allude to this process as well as helping to create a timeline of events, each statement was coded as pertaining to events occurring Prior to, During, or Post the 2010-2013 Revision. For reference, the starting point of the 2010-2013 Revision refers to the formal construction of the Science

National Curriculum Working Party and Post refers to the time of its formal disbandment upon completion of the Science National Curriculum. An additional code of 'General' was also added to the schema to represent portions of the data that allude to curriculum revision in general or as a process. Table 6.10 lists the basis for these codes.

**Table 6.10 Timeframe Relative to the 2010-2013 Revision**

| Codes Used | Description |
|---|---|
| **Prior** | Data pertaining to events that occurred prior to the 2010-2013 Revision |
| **During** | Data pertaining to events that occurred during the 2010-2013 Revision |
| **Post** | Data pertaining to events that occurred after the 2010-2013 Revision process ended culminating in the publication of 2014 PoS |
| **General** | Data that do not specifically allude to a timeframe surrounding the 2010-2013 Revision |

For an example, let us revisit Oliver W's previous statement:

> "We were trying to sort of get in touch with Department of Education and suddenly at some point that actually worked and we found ourselves being invited to some events at the Department of Education to talk about the new science curriculum, specifically biology curriculum."
>
> Oliver W

Analysis of this statement resulted in a coding of 'During' as it refers to an event occurring during the 2010-2013 Revision. Color-coding for each group was added to visually represent the data more effectively. This allowed for an easier time in recognizing what each data point revealed about the chronological and sequential aspects of the developing case. Revisiting Figure 5.4 gives an example of how the preceding data points made by Oliver W were used to add another the aspect of Timeframe to the previous schema:

**Table 6.11 Excerpt from Oliver W Pedagogic Device Schema (Updated)**

| What did they say? (Utterance) | Field Represented Production Recontext(ORF,PRF) Reproduction | Timeframe General, Prior to 2010-2013 Revision, During 2010-2013 Revision, Post 2010-2013 Revision | Comments |
|---|---|---|---|
| "We were trying to sort of get in touch with Department of Education and suddenly at some point that actually worked and we found ourselves being invited to some events at the Department of Education to talk about the new science curriculum, specifically biology curriculum." | Recontext ORF | During | **Prior to the Revision the GfS program prioritized creating both professional development and classroom experiences, here the focused is shifting from individual teacher decisions to national policy** |
| "For a short period of time there was the idea that the exam boards would bid to be sole provider of examinations for particular subjects, which is quite an interesting idea but they were all very anxious about that." | Reproduction | General | **The variability amongst exam boards made affecting widespread change difficult, it left the possibility of genomics showing up on an exam up to chance** |

Combining both pedagogical field data and time data created a schema that could be used to develop a timeline of event. This was useful in examining what the current case reveals about the processes that determine and transform new research into pedagogic communication. This data also helped to develop a timeline of the case, establishing boundaries which help to further define the case. This coding was also useful in examining what the current case reveals about the application of the pedagogic device in the study of curriculum development.

## 6.4 Summary

In this chapter, I have laid out the methodological processes that informed the study as well as the methods of data collection and coding. As revealed through the literature review, curriculum can be heavily influenced by social and cultural factors so it was important to approach data collection and analysis from a perspective that could potentially catch the extent of these influences. Initially viewing the data through an inductive coding process led to highlighting key themes of genomics knowledge and its relevance to secondary students, the substance that should constitute its teaching, and the ways that knowledge would need to be transformed for this new audience. Further exploring these themes utilizing Bernstein's Pedagogic Device as a theoretical lens helped to establish coding processes centered on outlining the agents and motivations that led to the introduction of genomics into the curriculum. This acts as the means for examining how genomics knowledge is converted from research science to pedagogic communication and provides a way to more specifically identify the agents of the case and their interactions. Whenever possible, public documents were sought out to better facilitate analysis of participant data by the adding of context. In the next chapter, I will outline how the theoretical framework of Bernstein's Pedagogic Device was used as a lens to view the collected data and illuminate what processes occurred and how these came about in the case for genomics. This would continue the exploration of the themes highlighted and the examination of the case.

## Chapter 7: Theoretical Approach and Analysis of the Data

The research questions of this study are as follows: 1. How did genomics knowledge come to be introduced into the National Curriculum for England and 2. What does this reveal about the processes that transform newly developed science research into secondary science curricula and lessons? Studying these processes required exploring participant data and available documentation. Employing the previously described methods of both thematic and discourse analysis (6.3 Methodology), Bernstein's pedagogic device was used as a prism to view both participant data and documentation to address the research questions. In this chapter, I will outline how processes of analysis were applied to my data and what was revealed.

### 7.1 Analysis of the Data

As stated previously, the goal of this case study was to examine the circumstances that led to the introduction of genomics knowledge into the National Curriculum for England and to explore what that process may reveal about how new knowledge is transformed into pedagogic communication. Data was collected from participants with experience and expertise in the case and coded using processes described previously. Each process of coding participant data examined what was said or could be inferred about the case including those involved and their motivations, a timeline of events, and the fields of the pedagogic device. All of these codes and analysis were organized into schema that made it easier to examine portions of the data pertaining to the previously mentioned aspects of the case for contrast and comparison.

Participants were primarily asked to report their experiences with the case but were also asked about their perceptions about what was happening with others during the process when appropriate. This meant a allowing a certain level of speculation on the part of the participants when necessary. As a researcher, I take participant reporting as an indicator of how they experienced the case. I recognize that knowledge is not constructed in a vacuum and what each participant reports represents their interpretation of events through the lens of their previous experiences and social constructs. This acknowledgement informed analysis of what came out of the coding processes.

Coding processes helped to organize the data for further analysis into the case. Each set of participant data was examined based on the aforementioned processes of coding: 1. Initial Inductive Coding, 2. Coding for the Fields of the Pedagogic Device, 3. Coding for the Agents, 4. Coding for Motivations, and 5. Coding to Establish a Timeline. This led to comparisons and contrasts across each participant data set for these specific elements of the case. For example, when exploring the agents of the case, there were numerous observations about the various contributors to the 2010-2013 Revision process. Dean T makes reference to organizations such as the Wellcome Trust and the Royal Society of Biology:

> "The last changes to the NC, though they were chaotic, organizations like the Wellcome Trust and what's now called the Royal Society of Biology, that's a professional organization of biologists, had quite an effect on the changes. And both the Wellcome Trust and the Royal Society of Biology are pretty positive about updating what used to be called genetics."
>
> Dean T

Hannah A also refers to the Royal Society of Biology and also includes Nowgen as a contributor to the process:

> "As I understand it when the new specifications for commission by the Department for Education were being elaborated across all of science and not just genomics, the Royal Society of Biology and other organizations and Nowgen got together to advise effectively the Department for Education on what we thought would be the most ideal content for study or content subject specific or specifications at GCSC and A-level."
>
> Hannah A

Here there is general agreement amongst these participants as to the involvement of the Royal Society of Biology in the 2010-2013 Revision. This is consistent with other participant data sets so can be taken as accurate. As to the involvement of Nowgen, more participant data would be analyzed to determine the extent of their involvement. Susan B spoke to some directions the revision group were given at the start of the revision:

> "And at the beginning of the process when they gave us the brief for what we were supposed to be doing, we were asked to contact and talk to the people at Nowgen when we were starting to think about what should be done in terms of genomics in the curriculum."
>
> Susan B

These comments give us indication that not only was Nowgen a participant during the process, but that they came to the proceedings with some authority. There are other mentions of their influence throughout the data and comparisons of each formed the basis for determining the extent of their influence on the revision process to determine findings.

This process was carried out looking at all aspects of the case pertaining to the timeline, individuals and organizations involved, and aspects of the pedagogic device including the Production, Recontextualisation, and Reproduction fields and what can be inferred about each from examining this case. When necessary, documentation was also analyzed to contribute to the processes so conclusions could be drawn. This documentation was outlined previously (Table 6.2 Documentation Utilized for the Study). I believe this process has led to accurate assessment of the data and findings outlined through study of the case.

These processes of coding and analysis led to the discovering of several themes throughout the data concentrating on the concepts such as the relevance of genomics knowledge to secondary students and their futures, the ways in which secondary students were meant to interact with genomics knowledge, and the processes that transform new research knowledge. Each would be explored through exploration of the collected data.

## 7.2 The Timeline of the Case for Genomics

Using the interview data and published documentation, I was able to discern a general timeframe outlining the events that led to the inclusion of genomics into the National Curriculum and how England came to participate in international efforts in genomics research such as the Human Genome Project (HGP). Shortly before the completion of the HGP, England would invest significant resources in exploring genomics and its medical potential. This investment would create great incentive to see the public better informed in genomics knowledge resulting in greater interest in seeing it taught in schooling institutions. Using the data, I was able to determine key points in the timeframe that led to this result. Take the following utterance from Katie B:

> "Well, I know that genomics in science has become a much more hot topic since the Human Genome Project. The complexity of the genome is better understood now as a result which has had implications for the Mendelian view of genetics and for treating people with genetic conditions. But then it also has implications for education because the biology curricula at all levels, really before university, are based on the traditional view of genetics with very little mention of genomics."
>
> Katie B

Here Katie links the HGP and its implications for education. As multiple participants mention the HGP as a catalyst for wanting to see genomics knowledge recontextualised, it is included as the starting point of the timeline. Further significant events were uncovered this way. Katie B later goes on to explain:

> "I'm quite familiar with where the origins of this came from politically because the organization I worked for (Nowgen) was an organization set up coming out of a government white paper looking at the future of genetics."
>
> Katie B

The White Paper Katie B refers to is *Our Inheritance, Our Future*. Mentioned previously (Table 6.2), this document outlines how the Labour-led Government planned to take advantage of the medical potential of genomics knowledge meant to come out of the HGP. The white paper would serve as a basis for the establishment of the Genetics Knowledge Parks. According to the DoH, these organizations would work in partnership with the private sector to improve public understanding of genetic science (DoH, 2003). Due to its importance in outlining how the government planned to take advantage of newly emerging genomics knowledge from the endeavors such as the HGP, the publishing of this white paper was included in the timeline as a significant event.

Data analysis also revealed insights into the revision of the National Curriculum which would ultimately see the inclusion of genomics language. Ginny W, a participant in the 2010-2013 Revision, speaks to the process:

> "Even so, there was a big debate about what you need to know by the age of 16, which is the National Curriculum. Should you start with Mendelian genetics and get people to understand the mechanism of inheritance and then at advanced level go on to talk about the more recent advances and the way we look at genomics, population studies or should you do it the other way around? And we had arguments on both sides because you could start teaching genetics from looking at a population and the proportion of people with different attributes and so on but it's almost impossible to get fundamental changes."
>
> Ginny W

Here Ginny W outlines how discussions about the teaching of genetics played a role in the revision of the curriculum. These discussions are not surprising as this particular revision process resulted in the inclusion of genomics language into the curriculum for the first time. Other events surrounding the revision process were also identified. These include the initiation of the revision of the National Curriculum (2011), the public release of both Key Stage 3 (2013) and Key Stage 4 (2014) Science PoS documents, both of which included references to genomics, and the 2016 school year which marks the first year the newly revised curriculum would be taught. Utilizing the multiple schema previously mentioned, both participant data and documentation was used as a basis for the following findings.

Initially, this analysis revealed two seemingly separate processes. The first is a process of engaging the public with newly emerging genomics knowledge as the completion of the HGP came closer. This process includes the creation of the Genomics Knowledge Parks (GKPs) as outlined by *Our Inheritance, Our Future*. The development of the GKPs would lead to the creation of the Northwest Genetics Knowledge Park (Nowgen) and its remit of public engagement which would play key role in the current study. The second process is the revision of the National Curriculum and efforts to directly introduce secondary students to genomics knowledge. While these processes seem separate, the idea of increasing genomics knowledge amongst the public is the thread that connects them. When considered through the prism of the pedagogic device, the theme of increasing public knowledge represents the movement of genomics knowledge from esoteric to the mundane through multiple processes of recontextualisation.

The timetable appears below:

***Timetable of Key Events in the Recontextualisation of Genomics***

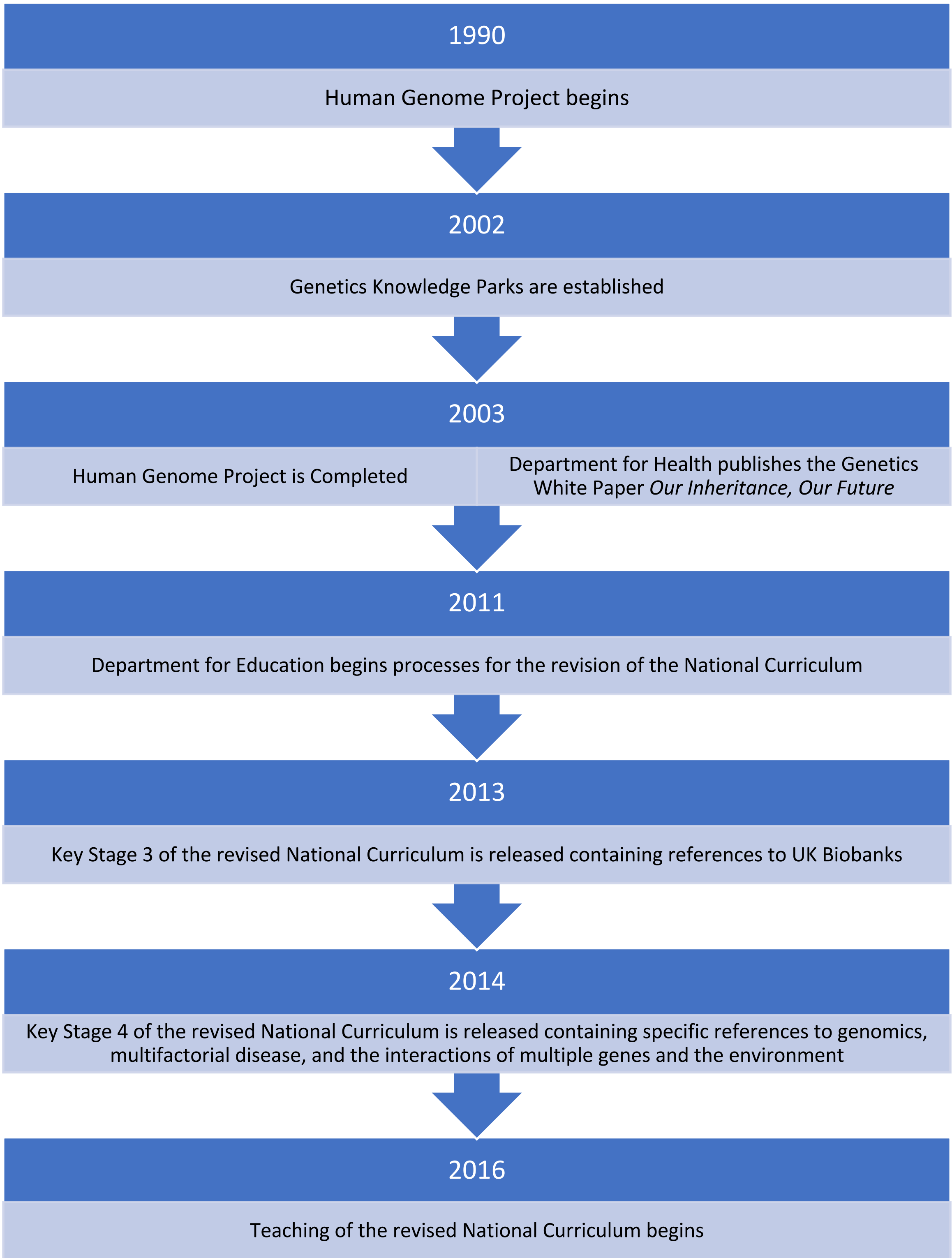


**Figure 7.1 From Research to Pedagogic Communication.** Here the recontextualisation of genomics from research knowledge towards specific pedagogic communication in the form of the curriculum is outlined.

While this timeline outlines specific events that led to the introduction of genomics to the National Curriculum, analysis of the collected data yielded further events that, when viewed through the pedagogic device, contributed to the recontextualisation of genomics knowledge.

### 7.3 Applying the Pedagogic Device to the Data

Exploring the processes that saw genomics introduced into the National Curriculum required the examination of several agents and the fields they compete in. Motivations amongst agents can vary but participant data points to the primary goals of those involved attempting to influence what appears in the National Curriculum regarding the teaching of genetics. While education and agents associated with education are at the forefront of the process, several agents occupying adjacent fields have the ability to influence the process of determining what knowledge is appropriate for school teaching and what form that teaching should look like. Each agent carries with them their own motivations and outlooks which inform how they view what should be taught in schools. Genomics and its introduction into the National Curriculum and secondary science courses was no different in this regard as agents representing educators, Government, the civil service, and several other organizations played a role. To better outline these agents, their interactions with other agents, and the influence they may have had on the recontextualisation of genomics knowledge towards the National Curriculum and secondary science courses, Bernstein's concept of *field* within the pedagogic device was used as a prism to explore and organize what participant data and documentation revealed about the interactions that saw genomics added to the National Curriculum. This analysis was also used to outline the distributive, recontextualising, and evaluative rules to devise a prism through which to explore the processes that saw genomics introduced into secondary science courses and the organizations which played a role in these processes.

Outlining the agents and ideologies also led to determining the *positioning*, the determination of power amongst agents on the field. As stated previously, Bernstein uses the concept of field in the same manner as Bourdieu (Singh, 2002). Both saw fields as a means of describing the competition between agents to collect resources or capital to achieve their desired outcomes. Positioning refers to where agents sit in their ability to gather resources. To an extent, positioning is a representation of power and influence on the field. Each agent has the ability to obtain resources and those with the best positioning have the greatest influence. For example, agents with established relationships with the DfE have a greater chance of influencing official processes of curriculum development. Methods of thematic analysis and discourse analysis were employed to analyze collected data. These methods have been outlined in Section 6.3 Methods.

There can be some complications with using Bernstein's concepts of field in this manner. Agents often overlap on fields and as such, there can be some problems with clearly delineating where one field ends and another begins. These complications can make highlighting how the interactions between agents can be defined using the pedagogic device difficult. To alleviate this issue, the discourse surrounding the interactions of agents was used as a means for inferring whether the interaction highlighted represented a process of knowledge production, recontextualisation, or reproduction.

There are also questions about the how each field approaches the suitability of knowledge from a cultural or historical background. Lamnias (2002) argues that historical and cultural influences within the field of production can limit what aspects of knowledge are suitable for recontextualisation despite the consent of agents with powerful positioning. While the powerful may prefer certain aspects of knowledge and value its recontextualisation, social norms and mores can play a significant role in what knowledge can be recontextualised. While this dispute can typically manifest itself as the powerful providing different forms of knowledge for different members of society (distributive rules), social-ideological contradictions at odds with society in general can have an effect on the official processes that select, classify, distribute, transmit, and evaluate school knowledge.

### 7.3.1 Who is Meant to Receive Genomics Knowledge? (The Field of Production)

This competition manifests itself primarily in the determination of who is meant to receive newly produced knowledge and how that knowledge will be distributed with the latter eventually delineating the *thinkable* from the *unthinkable* with thinkable knowledge consisting of approved knowledge to be taught in schools and unthinkable knowledge representing knowledge deemed unsuitable for school teaching (Wright & Froehlich, 2009). Through the establishing of the thinkable from the unthinkable, new knowledge begins its first steps from specialist to non-specialist. As the field of production is predominantly concerned with who is meant to receive new knowledge, questions about what is thinkable versus unthinkable are formed. The result is the knowledge meant for non-specialist use (mundane) is typically designated as thinkable with schools used as a means of propagating it. While the field of production determines what is suitable for teaching in schools it is actually the field of recontextualisation that converts that knowledge into pedagogic communication. In this section I will concentrate on what analysis of the data reveals about the case when viewed through the lens of this aspect of the pedagogic device.

As the data here was considered through the lens of the field of production, findings are the result of looking at the data through analysis processes centered on the discussions surrounding the development of newly emerging genomics knowledge and its appropriate audience. Analysis of data coded based on the field of production yielded discussions about the nature of the audience for genomics knowledge with much of it centering on whom genomics knowledge is suitable for and why. This analysis included comparisons of participant experience and in situations where there was misalignment amongst reporting further sources were sought out to clear any discrepancies.

The basis for comparing and analyzing data came from the schema developed during the coding processes outlined previously (6.3.6 Methods for Coding Data). The coding processes focused on the integral areas of the fields of the pedagogic device, agents, motivation, and timing making it easier to compare and contrast participant utterances allowing for recurring themes across sets to be highlighted. What is highlighted in the coming sections represent multiple mentions of particular themes amongst participants regarding the appropriate audience for newly emerging genomics knowledge and the different ways they were discussed. These themes arose from explorations of the aforementioned coding processes.

Table 7.1 outlines the key points, timelines, discrepancies, and resolutions pertaining to the analysis of the data through the lens of the field of production and some observations made that led to the determined findings.

**Table 7.1 Points of Interest from the Field of Production**

| Key Observations (Timing) | Sources | Possible Discrepancies | Resolution |
|---|---|---|---|
| The Labour-led Government seeks to take advantage of newly emerging genomics knowledge from the Human Genome Project (2003, 2008) | Hannah A, Cedric D, Katie B, Oliver W, Ginny W<br><br>*Our Inheritance, Our Future* (2003)<br><br>*Our, Inheritance, Our Future Progress Summary* (2008)<br><br>*Government Response to the House of Lords Science and Technology Committee into Genomic Medicine* (2009) | Genomics knowledge for the public vs medical professionals | Documentation was compared to participant data confirming initial emphasis on medical students then a shift towards the public writ large |
| Review and discussion surrounding who needs to be aware of new genomics knowledge (2003-2012) | Hannah A, Cedric D, Katie B, Oliver W, Ginny W<br><br>*Our Inheritance, Our Future* (2003)<br><br>*Our, Inheritance, Our Future Progress Summary* (2008)<br><br>*A Modern Education in School Science: A Manifesto for Change* (2012) | Public engagement vs engagement through school | Review of documentation revealed little mention of secondary schools as a part of public engagement initially but agreement later that schools should be involved |
| Who is involved or not involved? Who has influence? (2003-2016?) | Hannah A, Cedric D, Katie B, Oliver W, Ginny W<br><br>*Our Inheritance, Our Future* (2003)<br><br>*Our, Inheritance, Our Future Progress Summary* (2008)<br><br>*A Modern Education in School Science: A Manifesto for Change* (2012) | Mentions of many partnerships hint at many participants and multiple levels of influence | Comparisons across participant data and documentation reveal levels of both direct and indirect influence through things like support, funding<br><br>*Differences were recorded for reporting |

Exploration of these themes and observations were used as a basis for the findings that were uncovered. In the next sections I will outline the exploration of these ideas through the lens of the pedagogic device.

### *7.3.1.1 The Competition*

According to the data, in the introduction of genomics knowledge into the National Curriculum and secondary science courses, a competition manifests itself in determining who is to receive genomics knowledge and how that knowledge is meant to be delivered. Here agents compete for the power to decide what knowledge is suitable for non-specialist use. This competition plays a big role in determining what knowledge is meant for students in schools and therefore requires separating thinkable knowledge from unthinkable knowledge. This separation is important as the key discussion, or competition, on this field is the determination of not only what knowledge will eventually require recontextualising, but also what knowledge *can* be recontextualised. The demarcation of thinkable and unthinkable genomics knowledge lays the grounds for this discussion and helps to establish what ideologies are important in determining what knowledge is meant for recontextualisation.

To explore the field of production and its competition, the data was analyzed for utterances pertaining to those factors that determined who was meant to receive genomics knowledge and those agents seeking influence. This analysis would include exploring the data for references towards specific target audiences for genomics knowledge and the means of delivering it to them. Specific utterances pertaining to whom genomics knowledge is meant for and how that audience was meant to obtain that knowledge were coded during this analysis. For example, when speaking about the origin of the Nowgen Schools Genomics Programme (NSGP), Hannah A revealed:

> "We inherited a project called the Nowgen Schools Genomics Programme which had successfully got funding from the Wellcome Trust to bridge the gap of what was being taught in the classroom around genetics and what was happening in laboratories and clinical research in genomics."
>
> Hannah A

Here Hannah A specifically identifies Nowgen as an agent seeking to spread genomics knowledge to students in schools. They want the influence to determine what aspects of genetics and genomics knowledge is suitable for secondary students and as such, desire to choose which of these aspects are appropriate for recontextualisation. Hannah A also outlines a partner in Nowgen's pursuit, naming the Wellcome Trust as a funding source. This utterance represents a direct interaction between Nowgen and the Wellcome Trust and some degree of alignment in the goals of the agents can be inferred. It is unlikely the Wellcome Trust would fund a project that failed to align with their ideals, so some measure of agreement between the agents can be speculated upon. This utterance represents an interaction between agents seeking to influence the discernment of mundane from esoteric genetics and genomics knowledge, a competition of the field of production. As the field of production establishes both new forms of knowledge and the suitable audience for that knowledge, this utterance can be considered noteworthy. It is possible to glean more as the participant expounds on her experiences with introducing genomics knowledge to secondary students. Here, Hannah A continues to provide some insight into the nature of NSGP:

> "So largely broadly speaking, in the classroom, traditional Mendelian genetics were being taught but in clinical research, clinical practice, and in laboratory-based research it was much more the era of genomics and large-scale association studies and genetic variation and generally a much different, complementary to, but different picture to the Mendelian genetics being taught in the schools. So, the project set about to narrow this gap."
>
> Hannah A

Now Hannah A reveals something about the relationship between Nowgen and the Wellcome Trust. The desire to align what students are learning in secondary science courses with what is currently happening in genetics and genomics research gives insight into why both agents seek to influence the spread of genomics knowledge to students. This desire influence represents an aspect of ideology, or what Bourdieu would call "tastes" and helps to further define the agent's position on the field of production. In outlining the agents and interactions of the field of production, the distributive rules, those rules that determine who will receive any newly produced knowledge, can be established.

#### *7.3.1.2 The Agents and Motivations*

Through the analysis of participant data and documentation, several agents participating in the competition to determine who is meant to receive genomics knowledge were identified. Utilizing both thematic and discourse analyses and Bourdieu's concepts of *habitus* and *tastes,* it was possible to discern that each agent brings with them their own sense of motivation and tastes in pursuing their individual outcomes. While these outcomes can overlap, they often connect agents in different ways and exploring these connections can help to determine where they occur and how they affect the processes of knowledge production. Hannah A outlined the role Nowgen played in competing to determine whether genomics knowledge was meant for the National Curriculum and secondary science students, but further analysis of the collected data reveals more.

As stated previously, the Labour Government and specifically the Department of Health (DoH) outlined plans to raise public knowledge of genomics as a means of preparing for its potential application in medicine (DoH, 2003). Progress reviews reveal these efforts continued through multiple governments (DoH, 2008). This desire to see more members of the public made aware of genomics knowledge would eventually form the basis for wanting to see some aspects of genomics knowledge added to the National Curriculum and marks both the Government and the DoH as agents on the field of production as they seek to determine who gains access to genomics knowledge. This link between a desired increase in public understanding of genomics knowledge and its inclusion in the National Curriculum are further explored in the Discussion.

As mentioned earlier, the Wellcome Trust also sought some influence in determining who was meant to receive genomics knowledge. This idea consistently appears throughout the interview data and coincides with what is written in Nowgen and Department of Health documentation. Other participants also reference this idea. Cedric D also makes reference to the Welcome Trust seeking to determine who is meant to receive genomics knowledge:

> "As Wellcome became more and more closely involved with the public program to sequence the human genome at the end of the last century (Human Genome Project), at the start of century they upped the *ante* a little bit and at the same time there was a parallel greater interest in public engagement and those dimensions of science that were going to have an effect on people's lives. So, it was very much a gradual, if not a greater, shift from technical knowledge to social or economic implications of genetics in particular."
>
> Cedric D

The Wellcome Trust contributed both to the HGP and the previously mentioned Genomics Knowledge Parks established by the DoH (2003). Their involvement with the HGP fostered their desire to see greater public engagement with genomics knowledge placing them on the field of production.

#### *7.3.1.3 Initial Findings and Implications for Subsequent Fields*

Based on the analysis of participant data and documentation, it can be inferred that the introduction of genomics knowledge into secondary science courses was based on a desire to move it from "specialist" knowledge to "non-specialist" knowledge, or from esoteric to mundane. The data reveals a process of determining the appropriate audiences for genomics knowledge based initially on keeping it in specialist circles but eventually reaching the conclusion that the general public should be made aware of some aspects of it. This idea is outlined in the Government strategies listed in *Our Inheritance, Our Future* (DoH, 2003). *Our Inheritance, Our Future* also lays the groundwork for cooperation with non-government organizations, specifically listing the

Wellcome Trust as a partner. The desire to increase public understanding of genomics knowledge would eventually lead to a desire to use secondary schools as a means for distributing genomics knowledge with secondary science students determined to be a suitable audience. This idea would form the basis for the Nowgen Genomics Schools Programme which would be supported by the Wellcome Trust. A distributive rule based on giving access to the public can be inferred. This determination begins the process of moving genomics knowledge from esoteric to mundane, eventually leading to a decision that it should be taught in schools, identifying it as thinkable. Figure 7.2 outlines how the determination of audience eventually moves toward secondary students.

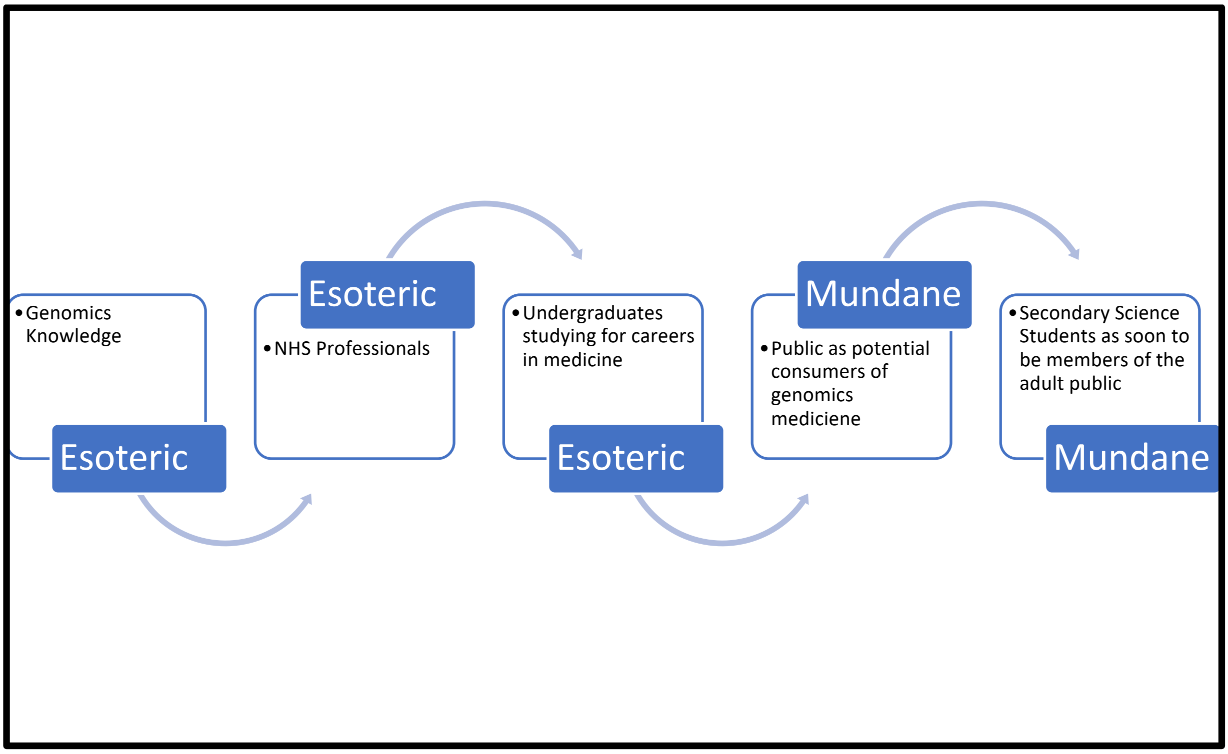


**Figure 7.2 From Specialist Knowledge to Non-Specialist Knowledge.** As the audience of new knowledge changes so does its designation as esoteric or mundane. Processes of recontextualisation will determine how new knowledge is converted based on the new audience.

It is important to note each determination of audience represents a competition amongst agents. Analyzing both participant data and documentation led to determining the outcomes of these discussions. While this may not have been the focus of the process that saw genomics introduced into the National Curriculum for England for some of my participants, these discussions are also outlined in the genetics white paper *Our Inheritance, Our Future*, its subsequent follow-up reports starting in 2008, and responses by organizations such as the Wellcome Trust and the Royal Society of Biology (then known as the Society of Biology). This represents an example of how further data was sought in circumstances where participants data was insufficient to make an inference.

According to the data, agents leading this drive are the Labour-led Government and its ministers who began the process later continued by the Conservative Government, the DoH with Nowgen, and the Wellcome Trust. Government in this sense refers to the governing Labour Party in consultation with the other agents. Amongst this group of agents, we see general agreement that the public require some access to genomics knowledge. This is the catalyst that begins its shift from esoteric to mundane where schools are eventually determined to be the best place to distribute such knowledge. While there is general agreement amongst the agents regarding genomics and the general public, there are questions about dissemination of knowledge and appropriate age levels. The interactions of multiple agents would result in the eventual determination of who is to receive genomics knowledge and its worth. While some agents may hold greater sway or power over the discussion and competition, many are given the opportunity to contribute. Table 7.1 outlines the agents identified through this analysis:

***Table 7.2. Agents Who Determine Who Receives Genomics Knowledge***

| Agent | Description |
|---|---|
| Government | Government is represented by the executive branch (Prime Minister and Cabinet) and legislative branch (Houses of Parliament). While a Labour government makes investment into genomics research it is actually Conservative Government in Coalition with the Liberal Democrats who begin to move genomics towards public use. Cabinet level officials typically drive departmental work. |
| Department of Health | The Department of Health supports ministers in leading the nation's health and social care to help people live more independent, healthier lives for longer (DoH, 2021). The Department of Health would establish the Genomics Knowledge Parks, some of which would specialize in public engagement. |
| Genetic Knowledge Parks (Nowgen) | The Genetics Knowledge Parks were established to carry out research into the implications of genetics for NHS services and the broader issues (DoH, 2008). The Northwest Genetics Knowledge Park (Nowgen) would specialize in public engagement and would lead efforts in seeing genomics knowledge being made available to the public. |
| The Wellcome Trust | The Wellcome Trust supports science to solve the urgent health challenges facing everyone through grant funding, advocacy campaigns, and partnerships (Wellcome Trust, 2018). They would partner with the Department of Health in providing funding for the Genomics Knowledge Parks including Nowgen. |

This analysis reveals a lack of official educational representation in this process of determining the appropriate audience for genomics knowledge. The process is primarily driven by desires of public engagement and initial mentions of schools as a means for spreading genomics knowledge are based in post-secondary experiences as opposed to secondary experiences as outlined by *Our Inheritance, Our Future* (DoH, 2003). Only after some time was the focus shifted to secondary students with Nowgen's establishing the Schools Genomics Programme (Nowgen, 2012). While this analysis reveals some insight into how genomics knowledge was determined to be suitable for secondary students, more analysis would be required to determine how the knowledge would be converted for this new audience.

### 7.3.2 Converting Genomics Knowledge to Pedagogic Communication (Recontextualisation)

Upon determination that some aspects of genomics knowledge are suitable for the public and eventually secondary students, a process of recontextualisation is required. To be truly integrated into secondary science classrooms, genomics knowledge required conversion from domain-specific specialist knowledge to knowledge appropriate for pedagogic communication in secondary courses. Discussions regarding this conversion help to determine how the process should take place and how any recontextualised genomics knowledge was meant to be communicated to both teachers and eventually students.

As with the field of production, data pertaining to the recontextualisation of genomics knowledge towards a secondary science discourse was compared across participants along with documentation to determine what is at the heart of the case. Analysis of both participant data and documentation was used as a basis for determining what the case revealed when viewed through the lens of recontextualisation. This process of analysis centered on comparing aspects of the data pertaining to the processes that transform genomics knowledge from a research science discourse to one based on secondary science teaching and learning. While the previous analysis revealed findings based on discussions surrounding the appropriate audience for newly emerging genomics knowledge, specifically secondary students, these findings center on how that knowledge is transformed into the science curricula and lessons. Table 7.3 outlines some of the key aspects of the data that helped to determine some findings as well as some of the discrepancies within the data and how they were resolved.

**Table 7.3 Points of Interest from the Field of Recontextualisation**

| Key Observations (Timing) | Sources | Possible Discrepancies | Resolution |
|---|---|---|---|
| Nowgen Schools Genomics Programme Collaborators (2009-2016) | Ginny W, Oliver W, Cedric D, Hannah A, Katie B<br><br>*Our Inheritance, Our Future* (2003)<br><br>*Our, Inheritance, Our Future Progress Summary* (2008)<br><br>*A Modern Education in School Science: A Manifesto for Change* (2012) | Role of government and outside groups in development of the program | Data from white papers and manifestos outline a government plan which was compared to participant data |
| 2010-2013 Revision SNCWP Make-up and Influence (2011-2016) | Dean T, Ginny W, Oliver W, Susan B, Katie B<br><br>*Science Programmes of Study Key Stages 3,4* (2013,2014)<br><br>*Reforming the National Curriculum in England: Summary Report of the July to August 2013 Consultation on the Programmes of Study and Attainment Targets from September 2014* (2013) | Who contributed to the process?<br><br>Who had the most influence? | Comparisons were made across each set of data and findings drawn based on majority consensus and resulting documents<br><br>*Differences were recorded for reporting |
| 2010-2013 Revision and outside Influences (2011-2016) | Dean T, Ginny W, Oliver W, Susan B, Katie B<br><br>*A Modern Education in School Science: A Manifesto for Change* (2012)<br><br>*Science Programmes of Study Key Stages 3,4* (2013,2014)<br><br>*The Framework of the National Curriculum: A Report by the Expert Panel for the National Curriculum Review* (2011) | Extent of influence by outside groups such as the Wellcome Trust and Nowgen | Comparisons across participant data and reviewed documentation reveal general agreement on the influence of WT and Nowgen directly or indirectly<br><br>*Differences were recorded for reporting |

#### *7.3.2.1 The Competition*

The competition to influence the conversion of genomics knowledge into pedagogic communication encapsulates the field of recontextualisation. To investigate the nature of these competitions, aspects of the data pertaining to agents seeking to control how genomics knowledge is converted into pedagogic communication were sought. As with the field of production, data points pertaining to the recontextualisation of genomics knowledge were used to highlight any agents seeking influence in the process, their ideologies and tastes, and the interactions between agents in their competition for resources. Genomics comes to be converted into pedagogic communication in two ways:

1. Nowgen Schools Genomics Programme (Pedagogic Recontextualisation).

As previously stated, Nowgen sought some influence in seeing more students introduced to genomics knowledge through its Genomics for Schools Programme. Prior to the introduction of genomics into the National Curriculum, Nowgen and its Schools Genomics Programme worked to develop teacher resources and learning experiences centered on training teachers to instruct students on genomics. Cedric D, formerly of Nowgen, speaks to these goals:

> "There was some curriculum development activity which was meant as exemplification, what we (Nowgen) were trying to do was to show how teachers' knowledge and competence (in teaching genomics) could be changed through the development of some materials."
>
> Cedric D

Here Cedric D recognizes Nowgen's desire to influence the teaching of genomics through the development of teacher resources. He makes connections between teacher competence and the resources they are provided. This connection can be used to outline Nowgen as an agent in the recontextualisation of genomics knowledge, more specifically an agent seeking influence on the field of pedagogic recontextualisation (PRF). Portions from Nowgen's *Modern Genetics Education in School Science: A Manifesto for Change* (2012) specifically outline the aims of the program:

> "In 2009, Nowgen embarked on a program aiming to raise awareness of the importance of presenting young people with key concepts in modern genetics and to promote change in how genetics is taught in schools. The Nowgen Schools Genomics Programme, supported by the Wellcome Trust, set out to provide teachers with contexts, resources and mechanisms for introducing modern genetics into their teaching, and to narrow the gap between scientific research and school students' classroom experience."
>
> Nowgen, 2012, p. 3

Viewing Nowgen as an educational organization geared towards affecting the conversion of genomics knowledge through the development of teaching resources and training is consistent with Bernstein's concept of the pedagogic recontextualising field and pedagogic agents.

Exploration of participant data reveals that Nowgen connected with other organizations in this this process of converting genomics knowledge into teacher resources and in doing so established relationships with other organizations and individuals with similar viewpoints. These partnerships form an initial basis for a network of those seeking to affect genetics and genomics teaching at the secondary level. Cedric D would go on to provide a detailed list of partners that Nowgen would work with in pursuing their goal:

> "And we had a series of partners for this because we realized it needed a multiagency approach and there would be a huge strength in doing so. So we had academic genetics researchers in the form of the team at the Manchester University who had Wellcome Trust funding. We had a department from the university who had led the Human Genome Project work at Sanger, who had moved to Manchester to work with an ethicist and philosopher and they were supporters of the ethical social implications of this. We had the Nuffield Curriculum Center, part of the Nuffield Foundation."
>
> Cedric D

These partnerships highlight at least some level of agreement with Nowgen's goal of converting genomics knowledge into pedagogic communication. Of note in these partnerships are the Wellcome Trust and the Nuffield Foundation and their willingness to partner with universities. The Wellcome Trust continues to show its support for the recontextualisation of genomics knowledge and the Nuffield Foundation and its history of curriculum development provide a strong presence in its direct conversion to pedagogic communication.

2. 2010-2013 Revision to the National Curriculum (Official Recontextualisation). Influencing the conversion of genomics knowledge through professional development and resources represents one aspect of the processes that saw its transformation into pedagogic communication. As mentioned previously, the introduction of genomics knowledge into secondary courses was also precipitated by the 2010-2013 Revision to the National Curriculum, a process of official recontextualisation. Driven by a newly elected Conservative Government in coalition with the Liberal Democrats in 2010, the

results of this process would see specific genomics language added to the National Curriculum for the first time. Dean T, a participant in the 2010-2013 Revision process and science education academic, had this to say:

> "The last changes to the NC, though they were chaotic, organizations like the Wellcome Trust and what's now called the Royal Society of Biology, that's a professional organization of biologists, had quite an effect on the changes. And both the Wellcome Trust and the Royal Society of Biology are pretty positive about updating what used to be called genetics."
>
> Dean T

Dean T makes specific references to agents participating in this process of official recontextualisation. He lists both the Wellcome Trust and the Royal Society of Biology as having had quite an effect on the process, even going as far to outline how pleased both agents were with the results. This data gives us insight into two specific official agents giving some shape to the field as well as their positioning.

While the NSGP provided genomics knowledge to teachers who had access to it, the introduction of genomics into the National Curriculum represents a larger effort to affect its teaching in schools. To further explore what the data revealed about this process of official recontextualisation, diagrams were created to represent how participants viewed this process which would determine what aspects of genetics and inheritance should be included in the National Curriculum for England. These charts would reveal whom each participant saw as agents, whom each agent consistently interacted with, and how those interactions affected the process of recontextualisation through the extrapolation of power structures established during these processes. The goal would be to represent each participant's views of the interactions of the agents involved in seeing genomics added to the National Curriculum during its 2010-2013 Revision. Employing Braun and Clark's method of thematic analysis as outlined in previous chapters, interview data was examined to extrapolate agents and interactions (Braun & Clarke, 2006). The previously mentioned coding schema were used as a means for developing an understanding of how each participant viewed this process and those involved.

This coding process led to the isolating of data surrounding the 2010-2013 Revision which could be used to define how each participant viewed the process. For example, take the following statement by Dean T:

> "At the national level what happens, and what still happens, is the government puts together a group of so-called experts. So I was one of the experts on the Science National Curriculum Working Party, as it was called."
>
> Dean T

Here the participant establishes the working relationship between the government and the Science National Curriculum Working Party (SNCWP), the group of experts asked to consult with the DfE on the revision of the National Curriculum. This firmly establishes the Government and Civil Service, bureaucratic members of the DfE, in a position of authority during the process. Dean T later lends more credence to this argument mentioning the Government's ability to steer the direction of the revision, saying:

> "First of all, we had this very strong steer that it was going to have to be knowledge strong. Oh, definitely, no secrets, this is Michael Gove (Secretary of State for Education), Nick Gibb (Minister of State for Schools) and the Conservative Government. The experts always know that it's up to what the government wants, it's a consultation so it's all quite open."
>
> Dean T

The nature of the relationship between the Government, the Civil Service, and the SNCWP is straightforward, with the working party taking their direction from the Government. According to Dean T, the Government holds greater power in this interaction. To represent the differences in the power structure established by each participant, the phrases *Primary, Secondary*, and *Tertiary agent* are used to exhibit whom the participant views as holding the power in these interactions with primary agents holding the greatest power and tertiary agents holding the least. For example, according to Dean T, Government gives direction to the SNCWP, so in their interactions, they are represented as a primary agent, one who holds direct power over the processes of recontextualisation. According to Dean T, they hold the power to steer the revision in a particular direction as well as having veto power over this process.

As they work in a consulting fashion recognizing the Government's authority during the process, members of the SNCWP represent Secondary Agents in their interactions with the Government and Civil Service. Figure 7.3 represents the interactions between the Government, Civil Service, and the National Curriculum Working Group as perceived by Dean T:

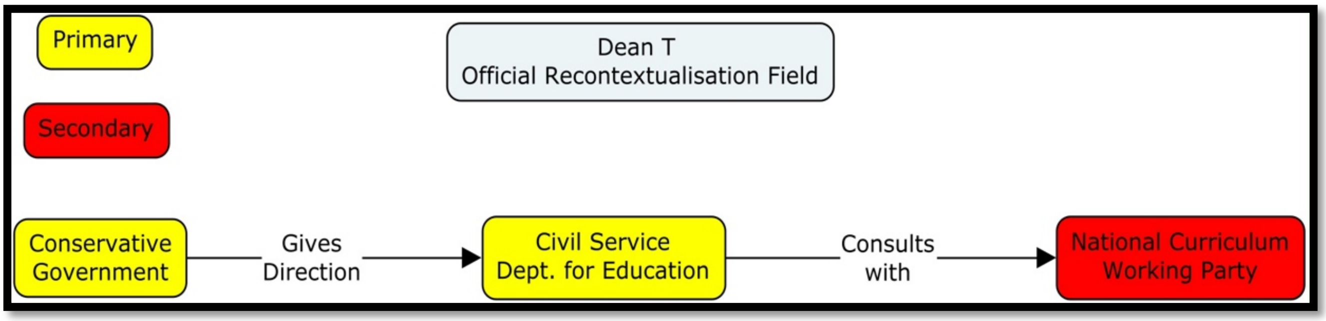


***Figure 7.3*** **Agent Interactions According to Dean T.** Here the relationship between the Government and the National Curriculum group is established as Dean T reports the Government hands down directions to the Working Group.

From here, Dean T goes on to expand the role of other agents on the field of Recontextualisation. He lists the make-up of the Science National Curriculum Working Party and gives some insight into the nature of the group's hierarchy, expanding the field.

> "They're a mixture. The most important people, being bluntly honest, tend to end up being people in universities and good science teachers in schools. It's almost impossible to get industry people on this. You get academic scientists on this, which is as good, but a small number. So they're useful but the nitty-gritty is usually done by schoolteachers, by university educators like me, and by people in the professional organizations like the Royal Society of Biology and the Wellcome Trust, those people."
>
> Dean T

Figure 7.4 outlines this expansion of the SNCWP:

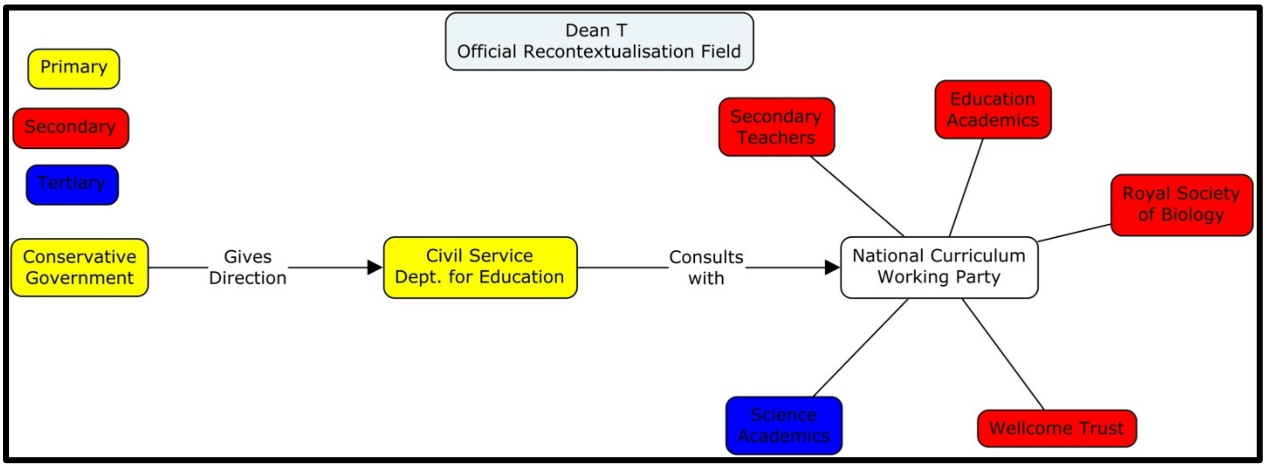


***Figure 7.4.* Agent Interactions according to Dean T.** More players are added to the previous players building a visual representation of the field and how these players interact.

Dean T presents secondary teachers, education academics, the Royal Society of Biology, and the Wellcome Trust as carrying out most of the work while diminishing the role of academic scientists. As such some agents are labeled as secondary agents, agents wielding less influence than primary agents, and others as tertiary agents who wield the least amount of influence. Dean T's data goes on to reveal how problems with the Civil Service brought about a change in the process due to problems that arose:

> "So the first version we got from the civil servants, which was just dire, would not be accepted as a first draft from a Master's student."
>
> Dean T

This led to changes in the processes and the SNCWP would go on to advise the Government and Civil Service to bring in a consultant to draft the curriculum:

> "But what Liz Truss (then Parliamentary Under-Secretary of State at the Department for Education) then did was ask us what needs to be done and we said, 'You need to employ, as a consultant, somebody who either is a classroom teacher or has been one recently who knows about school biology lessons and children.' And she asked for my advice and I suggested someone who thankfully they took onboard a science writer who worked on it."
>
> Dean T

This utterance outlines the adding of a drafter to the curriculum, someone who could work with the Civil Service to focus the process of curriculum development. From this point, the drafter would work with the SNCWP to write documents that could be presented to the Civil Service who in turn, would make adjustments and present it to the Government. The interactions make the drafter an intermediate between the Civil Service and the SNCWP establishing a new branch of relationships within the growing collective. This process of consistent working, reviewing, and modifying between the Civil Service, the drafter, and the SNCWP would continue until a satisfactory curriculum was developed. Figure 7.5 represents how this process was reported and outlined according to utterances from Dean T:

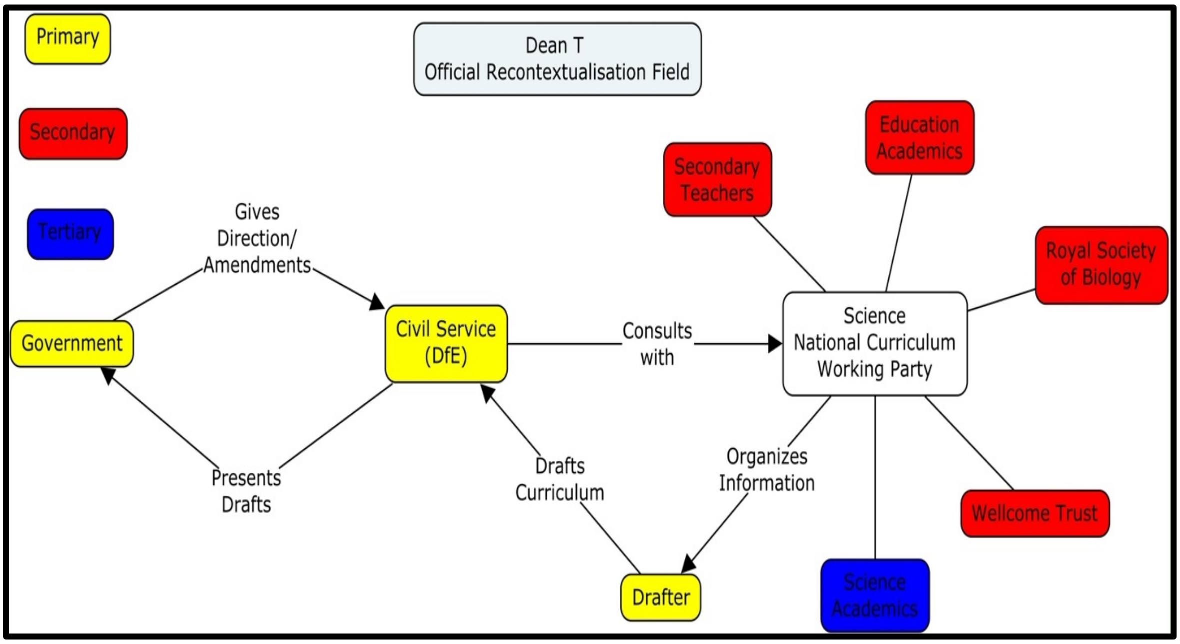


***Figure 7.5*** **The Interactions of Agents surrounding the National Curriculum according to Dean T.** According to the data of Dean T process can be described as a collaborative, although top down, approach to curriculum design.

Here we see a representation of how this participant views the process of curriculum revision that led to the introduction of genomics knowledge into the National Curriculum. Through these ORF Charts we are given some indication of the agents involved in the official process and the perceived power structure.

A diagram was created based on data from each participant. These diagrams allowed for comparison across multiple data sources. Many agents were identified as contributing to the genetics portion of the National Curriculum during this process. These charts form the basis for comparing each participant's experience of the revision process while also helping to develop an overall view of the power structures involved. Comparisons of these power structures help to create a clearer picture as to who was involved in the process and the extent of their influence and contributions. Highlighting the similarities and differences help to determine what is really at play in the case.

#### *7.3.2.2 The Agents and Motivations*

The analysis of data resulted in the identification of both pedagogic and official agents seeking to regulate the conversion of genomics knowledge into pedagogic communication. There is some overlap between agents who contributed to the recontextualisation of genomics knowledge through pedagogic and through official means.

**Nowgen Schools Genomics Programme.** As noted previously, the NSGP was devised to raise awareness of the importance of presenting young people with key concepts in modern genetics and to promote change in genetics teaching in schools. The program represented an effort by several partnering organizations to shift genetics education (Nowgen, 2012). This effort would encompass the creation of teacher resources and professional development opportunities geared towards shifting the focus of genetics teaching from the single gene Mendelian model towards a multiple-gene genomics model. To accomplish this task, Nowgen, already under the governance of the DoH, would partner with several universities and organizations including the Wellcome Trust and the Nuffield Foundation. This partnership would solidify the three as agents working to convert genomics knowledge from esoteric towards mundane through the development of teacher resources. This direct work with teachers places these three agents on the pedagogic recontextualisation field.

**2010-2013 Revision to the National Curriculum.** As a process of official recontextualisation, the 2010-2013 Revision represents the recontextualisation of genomics knowledge through government and policymaking means. As outlined earlier, numerous agents participated in this process including the Conservative Government, DfE, and the SNCWP which included in its makeup the following: secondary science teachers, science education academics, representatives from Nowgen, learned societies (specifically the Royal Society of Biology), and a curriculum drafter tasked with organizing the obtained information and drafting a curriculum. Representatives from each of the aforementioned groups contributed to the revision process which would ultimately see genomics added to the National Curriculum. Within the listed agents are also sub-groups such as research and industry scientists who also played a role.

Exploring the previously mentioned ORF charts helped to create a visual representation of how participants viewed the process and those involved. There was often overlap in who participants saw as the principal agents of the 2010-2013 Revision although there were also differences in perceptions of power, power in this sense meaning the ability to influence the revision process and the National Curriculum. For example, take Susan B, participant in the 2010-2013 Revision, and her outlook on the Revision process:

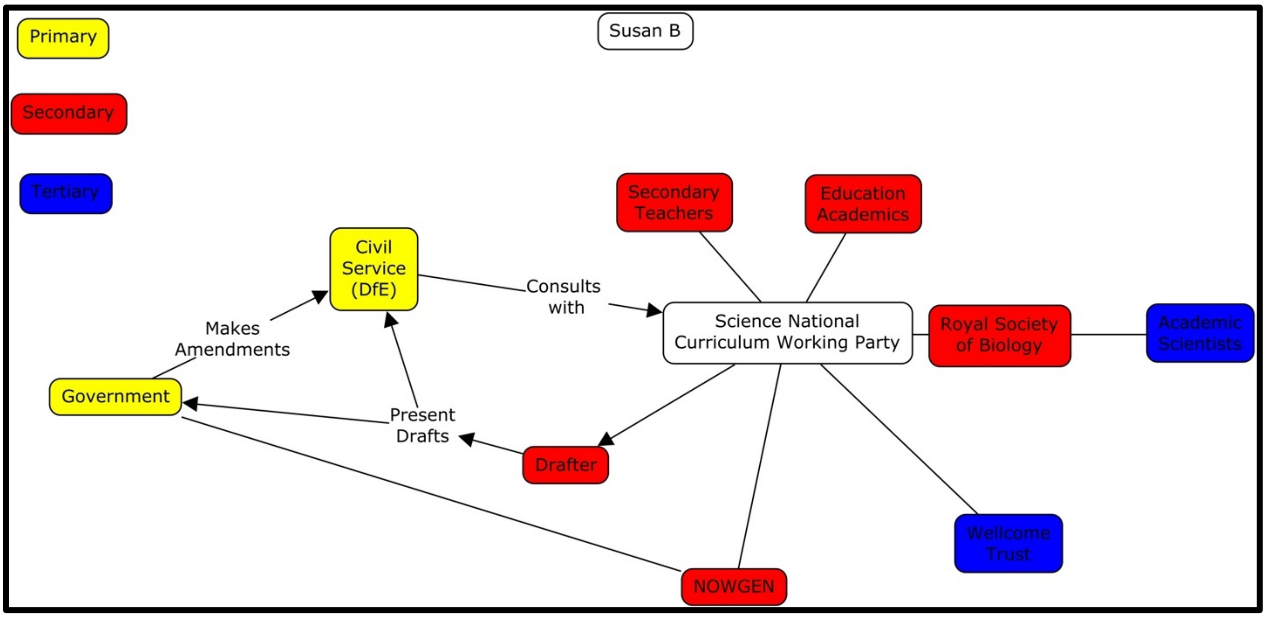

*Figure 7.6.* **The Interactions of Agents surrounding the National Curriculum according to Susan B.**

Susan B lists many of the same agents as Dean T when discussing the revision process:

> "The discussions I think were the ones that were really useful and where stuff absolutely got done were at the Royal Society of Biology largely where people from Wellcome, the Association for Science Education, the Learned Societies, and education professors would all come in various combinations and we'd call a meeting and sit around a table and look at aspects of the curriculum and tear it apart and build it up again and think about what is key and what we felt mattered."
>
> Susan B

Like Dean T, she outlines the Royal Society of Biology, education academics, and the Welcome Trust as playing a role during the revision process. She also makes mention of the Association for Science Education, a professional association of teachers, technicians, tutors, and advisors supporting science education from pre-school to higher education. Also like Dean T, she perceives a top-down process led by Government and the DfE:

> "You didn't see much of ministers, you just got certain instructions from them and with the biology education community (SNCWP) we'd kind of try and build up a curriculum that was acceptable to ministers but also acceptable to people who actually knew about it and going to deliver it."
>
> Susan B

Unlike Dean T, Susan B attributes less influence to the curriculum drafter. She also lists Nowgen by name, even going so far to note an endorsement of the organization by the Government:

> "We within the side of biology, worked with the Wellcome Trust and people like that but actually they weren't particularly the people that the Government wanted us to listen to. They (Government) wanted us to listen to an organization called Nowgen who had a particular perspective on genetics and genomics which we were directed to listen to."
>
> Susan B

Statements like this help to determine how participants viewed the power structure of the revision process. Susan B saw members of the SNCWP as working with the Wellcome Trust in some regard and in doing so attributes what can be described as an indirect influence by the organization. She also points out how the Government specifically directed the SNCWP to listen to Nowgen on matters of genetics and genomics creating a link between the two. When exploring this link through the lens of the pedagogic device, we can start to see Nowgen using their many affiliations to seemingly blur the lines between the PRF and ORF as they attempt to influence genetics teaching.

Comparing experiences like this will inevitably lead to differences. While agreement does help to shape the narrative of the case, it is differences like the ones highlighted above that truly tell the tale. In this particular case there was often general agreement about who was involved but differences in the extent of influence. These findings will be discussed at later points in this paper.

As noted previously, when these differences in the data arose other sources of data were sought out in attempts to better discern what was occurring. Documentation and the examination of participant data helped to develop a certain level of consensus surrounding the events and participant experiences. Both agreement and disagreement are noted within this paper. Of course, the differences in these experiences as highlighted by coding and analysis can really highlight the key aspects of the case. The process of developing the ORF charts was pivotal in comparing participant data regarding their experiences with the 2010-2013 Revision.

In Figure 7.7 Ginny W, a participant in the 2010-2013 Revision and former contributor to Nowgen and the Nuffield Centre, reports many of the same agents as Dean T and Susan B including both the Government and Royal Society of Biology:

> "So, the Conservatives closed QCA (Quality Curriculum Authority) when they came into power. It doesn't exist now and so the most recent curriculum change, it's difficult to say who drove it. They (Government) were happy for the three professional bodies, The Royal Society of Chemistry, the Institute of Physics, and the then Society of Biology, which is now the Royal Society of Biology, to take a lead."
>
> Ginny W

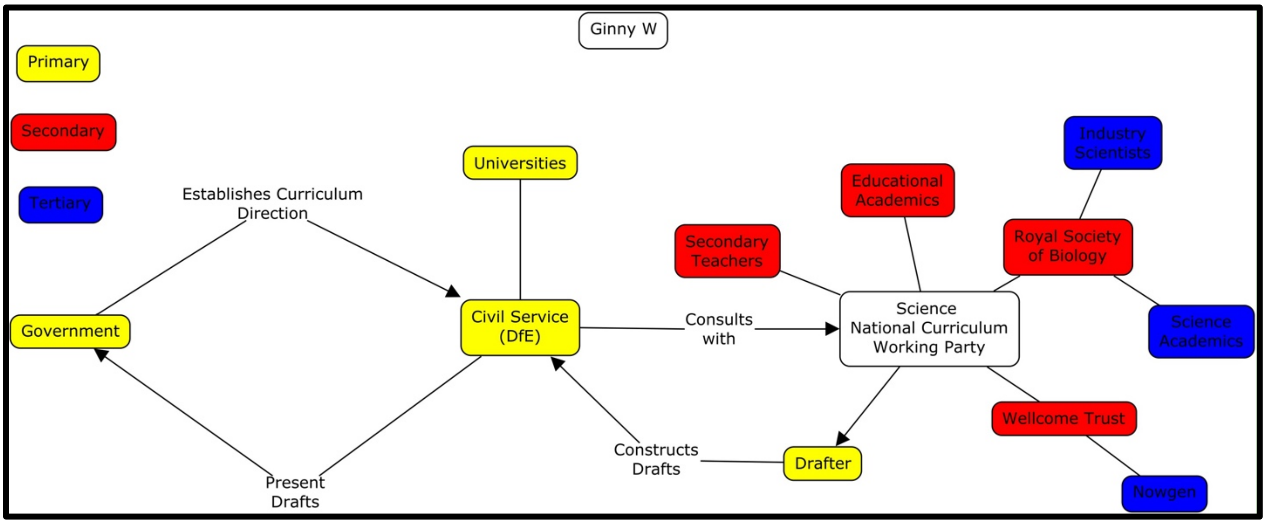


***Figure 7.7*** **The Interactions of Agents surrounding the National Curriculum according to Ginny W.**

Like Dean T and Susan B, Ginny W outlines a top-down process led by Government and the DfE Civil Service. She also directly links Nowgen and the Wellcome Trust, straightforwardly attributing some changes to the National Curriculum to this partnership:

> "So we did get some changes. And we were very strongly in touch with people at the Wellcome Trust who at the time was working on a big educational program for genomics in schools (Nowgen Schools Genomics Programme). They were very articulate and managed to sort of convince people."
>
> Ginny W

Ginny W directly attributes changes in the National Curriculum to the Wellcome Trust outlining their ability to move others towards their way of thinking. Unlike other participants she also adds Universities as an agent in influencing the process:

"So whenever there's a change in the curriculum there's a lot of employers involved in having a chat about what is needed but in the end but our education system is driven by university entrance requirements and that is A-Levels, and A-levels are designed according to what is needed by the universities for their undergraduate courses."

Ginny W

In Figure 7.8, Katie B, a former geneticist and contributor to Nowgen, has some similar views to both Susan B and Ginny W listing the Government and the DfE as key agents:

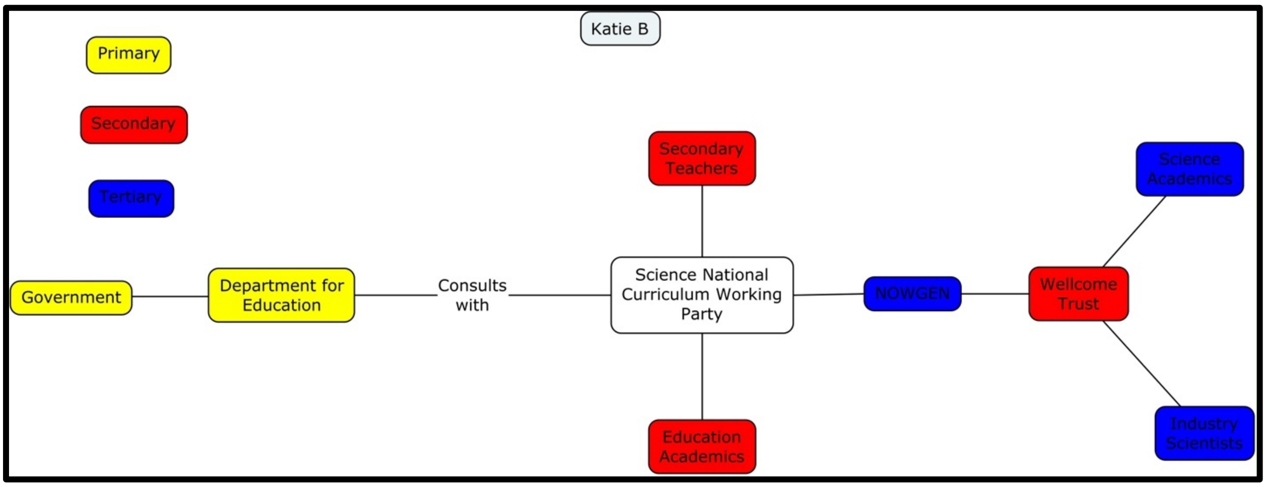


***Figure 7.8*** **The Interactions of Agents surrounding the National Curriculum according to Katie B.**

Like Ginny W, Katie B lists Nowgen and speaks to their desire to reform genetics teaching:

> "Because I think Nowgen was essentially more focused from the beginning whilst I think in London it was more still the old approach. Still looking at the same stuff that's in the curriculum, trying to bring in some interesting contexts, say from the clinical world. But the actual science was pretty much what everybody had already been learning for donkey's years. I think Manchester (Nowgen) were looking to innovate more."
>
> Katie B

Katie B also links Nowgen and the Wellcome Trust:

> "The Wellcome Trust have been interested in their (Nowgen's) work. Because if it is going to have had any impact, I would say it would be through that route, through a collaboration with the Wellcome Trust. But Nowgen are a small organization and they have a small voice in a very big political and social milieu. I don't think it's from, say, the work not being good or a lack of enthusiasm for it. I just think there's a lot of inertia."
>
> Katie B

Here Katie B gives some insight into where Nowgen fits within the power structure of the revision process while also outlining the importance of their connection with the Wellcome Trust. Unlike others, Katie B makes no mention of a Curriculum Drafter although she does give some insight into the role that teachers and science experts should play in the curriculum revision process:

> "Well, to be honest, I do think educators should have the final responsibility for shaping that curriculum under the advice of the scientific experts rather than the other way around. The trouble is a lot of very clever people think they understand education because they went to school."
>
> Katie B

Katie B also recognizes the importance of political capital attributing much of the changes seen in curriculum to political will revealing how much power Governments can wield:

> "So this year they're doing the new English and Maths GCSEs. The year behind them are doing the whole lot and everything has changed. But the reason those changed was because the government wanted them to change because they didn't think assessment was rigorous enough. And that was a political thing. Because another government came in with a totally different philosophy and wanted to change it all and take it back to something they remembered and understood."
>
> Katie B

In Figure 7.9, Oliver W, former contributor to Nowgen and participant in the 2010-2013 Revision, reveals a different take than previous participants:

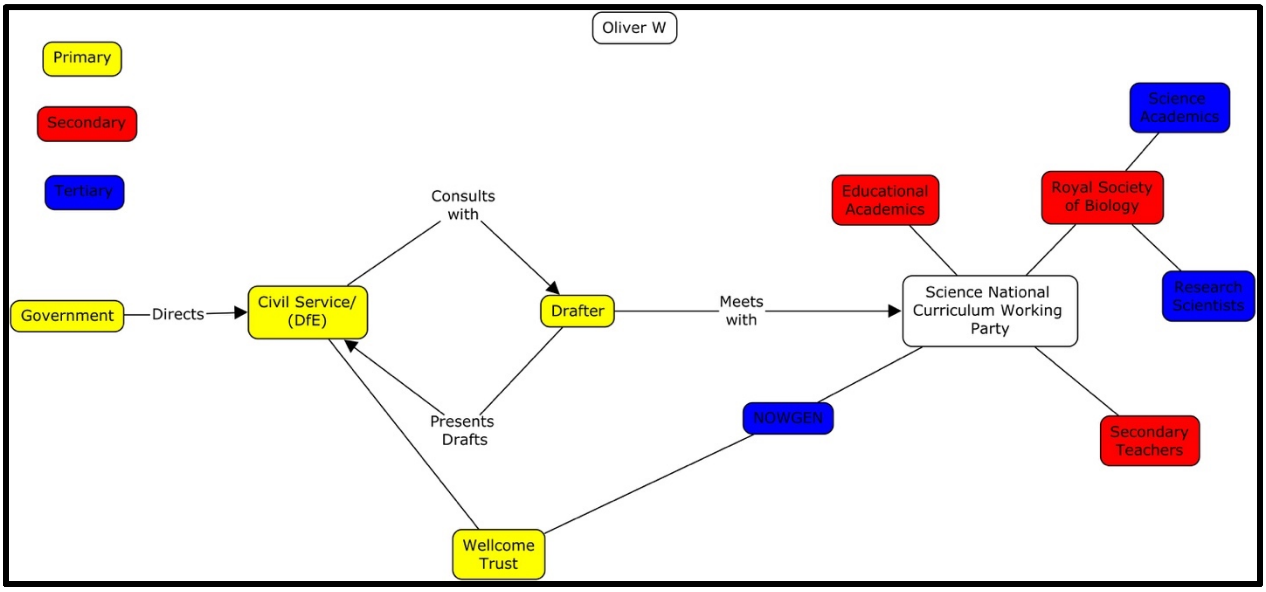


***Figure 7.9*** **The Interactions of Agents surrounding the National Curriculum according to Oliver W.**

Oliver W reports a process that directly links the Department of Education with the Wellcome Trust, attributing great power to both in determining the National Curriculum just like other participants:

> "Wellcome has a lot bigger influence over the Department for Education than Nowgen did with that. That was kind of where the opportunity came from because the project (Nowgen Schools Genomics Programme) was funded by Wellcome and we were happy to kind of see that and go forward."
>
> Oliver W

Unlike others, Oliver W directly links the Nowgen's participation in the 2010-2013 Revision to their connection with the Wellcome Trust. Oliver W also attributes significant power to the Curriculum Drafter:

> "We (Nowgen) were trying to sort of get in touch with Department of Education and suddenly, at some point, that actually worked, and we found ourselves being invited to some event to the Department of Education to talk about the new science curriculum, specifically biology curriculum. That was interesting but obviously I was talking about the breadth of things surrounding particular conversations around genetics. I think what was interesting was seeing how much one person influenced a content of the curriculum and that one person was commissioned by the Civil Service to essentially bring that all together."
>
> Oliver W

Oliver W sees the Drafter as a powerful gatekeeper for the process with a difficult job revolving around the task of consolidating several different voices into a singular document indicative of what is truly important for school age students to learn. Below he speaks to some of these difficulties:

> "And I do think it is a very difficult task for whoever that gatekeeper is because there are lots of different content areas within a subject that everybody thinks is really important. I think that is a challenge of the school curriculum. It only ever seems to grow, it's quite hard to take things out of it. Not least because people feel protective about their patch."
>
> Oliver W

Oliver W sees the Drafter as an individual with the ability to influence the process through their power as gatekeeper in determining what gets into the curriculum, a sentiment shared by other participants. This gatekeeping can give the Drafter a certain sense of outsized power when compared with the other participants in the curriculum development process.

Oliver W also notes a secondary process of recontextualisation occurring outside of the revision of the National Curriculum. When describing what he considered a small victory he had this to say:

> "We introduce the language of "variants", we got that word in there. We got that sentence in which we're quite pleased about but that's the National Curriculum. That's not the exam specifications. The exam boards then take that, and they go and interpret it and they change it. You won't find that particular clause in any of the exam specifications for example."
>
> Oliver W

Here, Oliver W is referencing what I will refer to as *secondary recontextualisation,* a process of recontextualisation that occurs when the exam boards, the organizations responsible for setting and awarding secondary qualifications, take the National Curriculum PoS and develop exam specifications. This process of recontextualisation and how it potentially affects the teaching of the revised curriculum will be explored later in this chapter.

In Figure 7.10 Cedric D, also a former contributor to Nowgen, echoes some of Oliver W's sentiments:

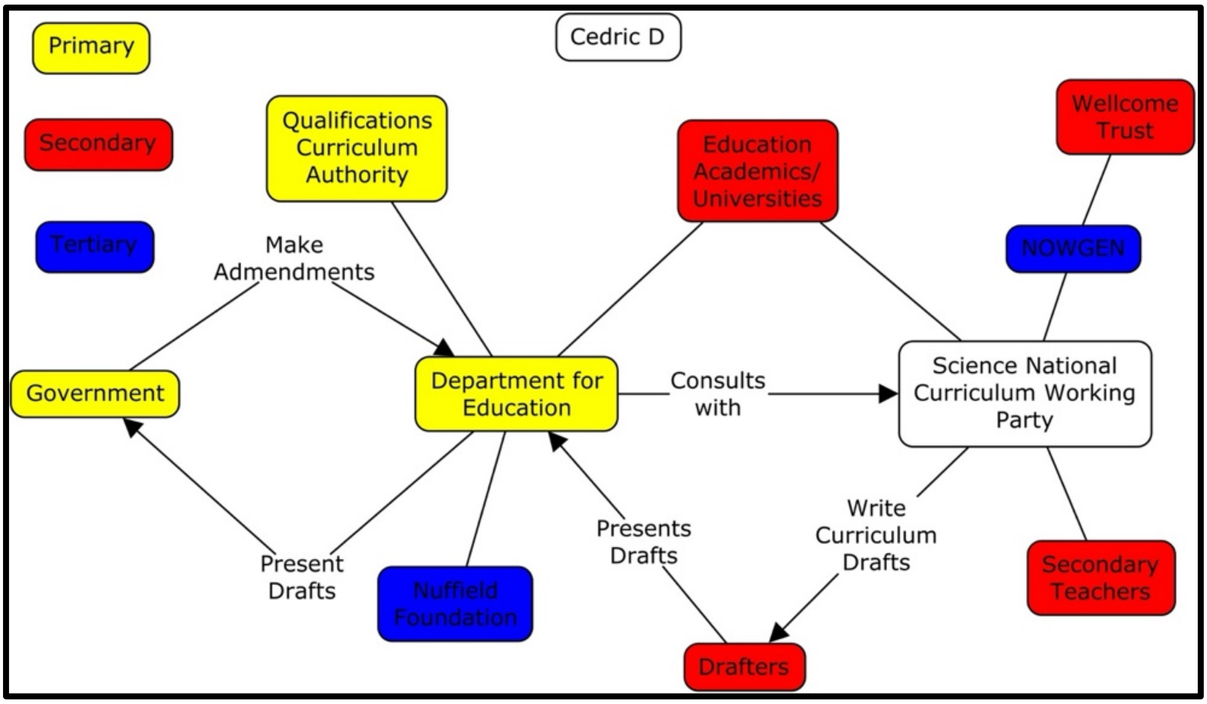


***Figure 7.10*** **The Interactions of Agents surrounding the National Curriculum according to Cedric D.**

Cedric D outlines a process where the DfE is far more accessible by educational organizations:

> "Back in those days, organizations like Salters-Nuffield or the University of York Science Education Group, like the IOE (Institute of Education) itself, were much more closely linked to the Department for Education. It relied on them much more as almost like agencies of expertise and wisdom and there was always a free flow of ideas from the officials of the Department for Education through those mediators."
>
> Cedric D

While recognizing the power the DfE wields, Cedric D describes a more collaborative partnership than others. He also mentions the Qualifications Curriculum Authority and its role in curriculum revision:

> "The QCA were a powerful agency who reported to the Department for Education. So, there was a mechanism. Working with their subject specialists and including them in seminars and keeping them informed and having meetings with them, there was a mechanism for doing that."
>
> Cedric D

Like other participants, Cedric D also reveals connections between the Government, the Wellcome Trust, and Nowgen. He makes particular note of the power the Wellcome Trust wields in policymaking:

> "I think the fact that we were funded by the Wellcome Trust and Wellcome is such a massive player in policy helped. It's not a policy entity but it's listened to by policymakers."
>
> Cedric D

Hannah A (Figure 7.11), former contributor to Nowgen, expresses a similar perception to others when describing the revision process:

"But it was a different story in England. So, as I understand it, when the new specifications for commission by the Department for Education were being elaborated across all of science, and not just genomics, the Royal Society of Biology and other organizations and us (Nowgen) got together to advise the Department for Education on what we thought would be the most ideal content for study or content subject specifications at GCSE and A-Level. And I think we could directly point to aspects of the new curriculum that we managed to change."

Hannah A

Hannah describes the same top-down process as others, attributing power to the Government and DfE.

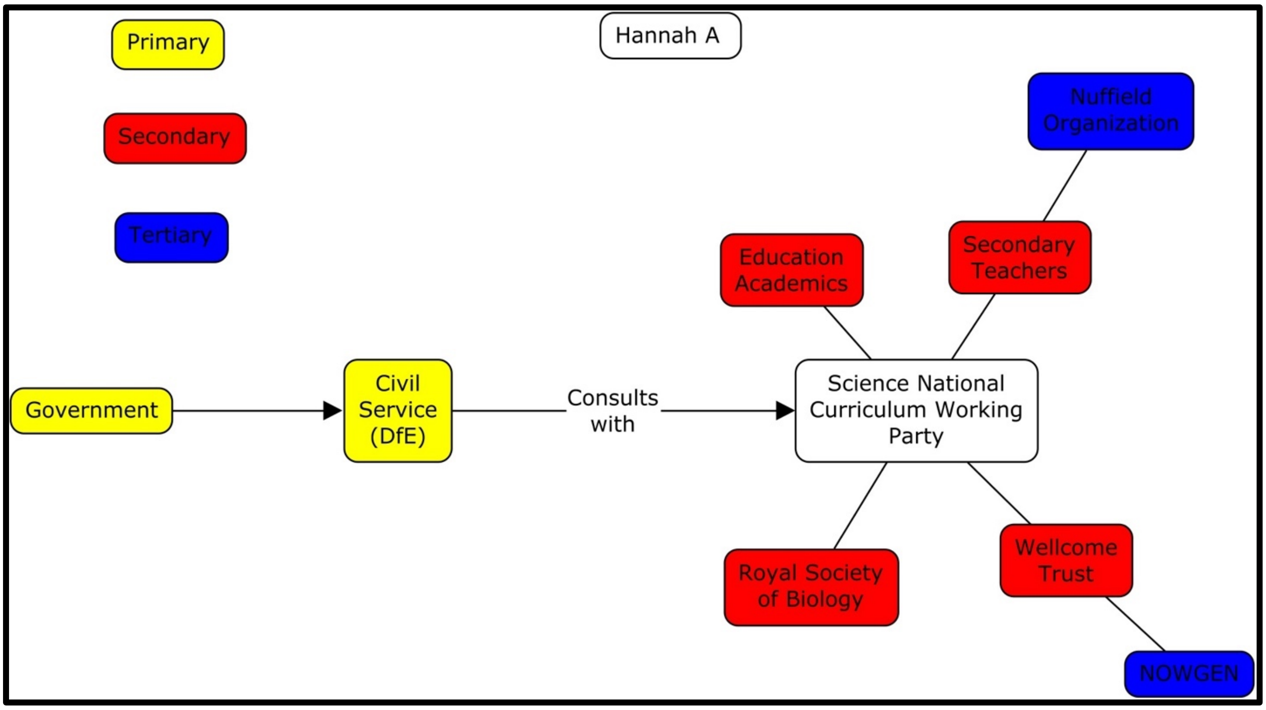


***Figure 7.11*** **The Interactions of Agents surrounding the National Curriculum according to Hannah A.**

Like others, Hannah sees Nowgen's ability to influence the process as tied to their connection with the Wellcome Trust. This link continues to manifest itself in this process of official recontextualisation.

In an effort to obtain an idea about how current teachers perceived the process of curriculum revision, an eighth participant unconnected to the 2010-2013 Revision process was sought out. As mentioned earlier, Marietta E is an experienced secondary science teacher who played no role in the recontextualisation of genomics knowledge through official or pedagogic processes. She does have significant experience teaching the genetics curriculum and therefore brings a perspective that would help to give insight into how a working teacher perceives the recontextualisation of knowledge.

As shown, the participant pool represents a diverse sample of individuals with a wealth of experience with the case and its boundaries. Each participant was asked to speak to their experiences through interviews which focused on the events leading to the 2010-2013 Revision processes that resulted in the addition of genomics knowledge to the National Curriculum for England. This data was then viewed through the prism of Bernstein's Pedagogic Device and analyzed utilizing both inductive and deductive coding processes. From here, the data was organized into table for further analysis and comparison.

Analysis of the data reveals insights into those individuals who played a distinct role in seeing genomics knowledge recontextualised towards secondary students through official processes. While many organizations played a role in seeing genomics knowledge transformed into pedagogic communication, the data reveals differences in the perception of power of those involved. Table 7.4 outlines these differences:

**Table 7.4. 2011 National Curriculum Revision Agents and Power**

| *Agents (Mentions)* | Dean | Susan | Ginny | Katie | Oliver | Cedric | Hannah |
|---|---|---|---|---|---|---|---|
| *Government (7)* | ***1*** | ***1*** | ***1*** | ***1*** | ***1*** | ***1*** | ***1*** |
| *Dept for Ed/Civil Service (7)* | ***1*** | ***1*** | ***1*** | ***1*** | ***1*** | ***1*** | ***1*** |
| *Teachers (7)* | ***2*** | ***2*** | ***2*** | ***2*** | ***2*** | ***2*** | ***2*** |
| *Ed. Academics (7)* | ***2*** | ***2*** | ***2*** | ***2*** | ***2*** | ***2*** | ***2*** |
| *Wellcome Trust (7)* | ***2*** | ***3*** | ***2*** | ***2*** | ***1*** | ***2*** | ***2*** |
| *Nowgen (6)* | ***x*** | ***2*** | ***3*** | ***3*** | ***3*** | ***3*** | ***3*** |
| *Drafter (5)* | ***1*** | ***2*** | ***1*** | ***x*** | ***1*** | ***2*** | ***x*** |
| *Royal Society of Biology (5)* | ***2*** | ***2*** | ***2*** | ***x*** | ***2*** | ***x*** | ***2*** |
| *Sci. Academics/Ind. Sci (5)* | ***3*** | ***3*** | ***3*** | ***3*** | ***3*** | ***x*** | ***x*** |
| *Nuffield Centre (2)* | ***x*** | ***x*** | ***x*** | ***x*** | ***x*** | ***3*** | ***3*** |
| *Universities (2)* | ***x*** | ***x*** | ***1*** | ***x*** | ***x*** | ***2*** | ***x*** |
| *Qualifications Curriculum Authority (1)* | ***x*** | ***x*** | ***x*** | ***x*** | ***x*** | ***1*** | ***x*** |

***1 - Participant reported agent as Primary (holds direct influence final draft of National Curriculum)***

***2 -Participant reported agent as Secondary (holds some, direct or indirect, influence on the drafts sent to the Department for Education/Government during the revision process)***

***3 - Participant reported the agent Tertiary (participated in the revision process but with little to no direct or indirect influence on the drafts during the revision process)***

***x – Participant did not report the agent***

Visually representing this data gives a good view of how the participants saw the power and power structure involved. Using the ORF charts as a basis we can specifically list which agents appear and how influential they were.

Participants generally saw the Government and the DfE as having the most power during the revision process. Participants also generally reported secondary teachers and educational academics as playing an influential part in the process. The Wellcome Trust is reported by each participant as playing a role, but there is some discrepancy about their level of influence. The same can be said of those who reported the curriculum drafter as playing a role. Of interest in this analysis is the reporting of Nowgen. According to most participants, Nowgen held minimal influence during the revision but, as alluded to earlier by Oliver W and Ginny W, language surrounding the concepts of genomics were ultimately entered into the National Curriculum Science PoS. It can be inferred that Nowgen's ability to exceed their power during this process can be tied to their affiliation with the Wellcome Trust. Several participants did connect the two organizations when discussing revision. Of course, there are instances of differing reports when it came to this aspect of the data. There was some disagreement about how influential the drafter was to the process with some reporting the drafter wielding significant power and others attributing very little to the role. Like with previous analysis, further examination resulted in more exploration through documentation in attempts to determine findings. This will be discussed in subsequent chapters.

#### *7.3.2.3 Initial Findings and Implications for Subsequent Fields*

Analysis of the data helped to outline important aspects in the recontextualisation of genomics knowledge. Firstly, there are organizations and power dynamics that played a role in the recontextualisation of genomic knowledge. This power dynamic influences the processes that determine how knowledge is meant to be converted into pedagogic communication (Pedagogic recontextualisation vs. Official recontextualisation) and the processes that determine what aspects of new knowledge warrant converting (What does the new audience need to know?). According to the literature, these processes of recontextualisation often occur simultaneously (Bertram, 2020; McCloat & Caraher, 2020; Wheelahan, 2005; Wright & Froehlich, 2009). This was also the case in the recontextualisation of genomics knowledge. Using these questions as a basis, we can examine the data for utterances surrounding conflicts centered on determining what aspects of genomics knowledge is meant to be translated into curricula documents and teacher resources in addition to how this is meant to occur. As mentioned previously, Katie B speaks to why genomics was considered for the process of recontextualisation:

> "Well I know that genomics in science has become a much more hot topic since the Human Genome Project. The complexity of the genome is better understood now as a result, which has had implications for the Mendelian view of genetics and also for treating people with genetic conditions. But then it also has implications for education because the biology curricula at all levels before university are based on the traditional view of genetics with very little mention of genomics."
>
> Katie B

As mentioned previously, while Mendelian genetics had dominated secondary science teaching of inheritance, the growing potential of the medical application of genomics slowly fueled an increasing desire for greater investment in both research and public engagement in this emerging field. As research yielded better understanding of the nature of the genome and greater technological advancements unlocked its medical potential, the value of genomics knowledge grew. This growth in value helps to form the basis for establishing secondary students as a suitable audience for genomics knowledge (*distribution rules*). This determination is led is established by several different agents and is important to highlight as it begins the process of transforming genomics knowledge from esoteric, specialist knowledge towards mundane knowledge meant for everyday use by non-specialist individuals. This determination led to questions surrounding what aspects of genomics knowledge secondary students need access to. Examining what the data reveals about these ideas, through the lens of the pedagogic device, allows us to begin to highlight the recontextualising rules of this field. As mentioned previously, these rules highlight what knowledge is meant to be converted into pedagogic communication and the criteria meant to make this determination.

When examining the data in this regard, the question of whether the inclusion of genomics in secondary science courses should *support* or *replace* the then currently taught Mendelian model comes to the forefront with some agents seeking to replace the teaching of the Mendelian model with the teaching of genomics in schools and others seeking to supplement the Mendelian model with genomics. Hannah A alludes to this debate when describing a Nowgen-led workshop held in junction with the Nuffield Centre:

> "This was a real bone of contention, actually, in the workshop at the Nuffield Centre and in the subsequent (Nowgen) manifesto. A first draft of the manifesto didn't mention Mendelian genetics and almost went as far as to say that the teaching of the new genomics should replace the teaching of any Mendelian genetics."
>
> Hannah A

When viewed through the pedagogic device, this debate highlights a key factor in the pedagogic recontextualisation of genomic knowledge. The question of genomics replacing or supplementing the currently taught Mendelian model in secondary schools also played a role in the 2010-2013 Revision processes. Susan B recounts conflict on the matter during this process:

> "I think the disconnect was on a number of levels, it wasn't that we disagreed about everything but the particular individual that we had to deal with is Nowgen had a particular take that really didn't want students to learn Mendalian genetics in any way and just wanted all that to go. He also had some very definite ideas about terminology. He wanted us to use the term "variant" instead of "allele"."
>
> Susan B

Here we actually see the conflict taking shape during official recontextualisation as agents debate the role of genomics in the curriculum. Based on the data, the specific processes that saw the conversion of genomics were centered on whether the Mendelian single gene model of inheritance sufficiently prepares students to interact with emerging genetics knowledge past secondary school. As discussed in the literature review (3.4 Why Study Genomics and the National Curriculum?), the Mendelian model of genetics, also referred to as the Classical Model, emphasizes teaching inheritance through the view of single gene interactions as opposed to the multiple gene genomics model which emphasizes exploration of multiple genes interactions and the role of an organism's genome in gene expression. Eventually a determination that genomics knowledge would supplement the already widely taught Mendelian model would be made.

> "Through consultation with our community and the people at the workshop, the (Nowgen) manifesto was revised to reflect that the teaching of genomics needs to include both Mendelian genetics and contemporary genomics."
>
> Hannah A

This determination is also echoed in the 2010-2013 Revision. Below Dean T refers to the outcomes of the process:

> "So although to somebody with a university level understanding of genomics it all looks pretty conventional, it is moving away from what now would probably thought to be a rather simplistic notion of genetics that education used to have."
>
> Dean T

Viewing these similar outcomes through the lens of the pedagogic device and combining them with the power dynamics outlined previously, we can begin to examine how Nowgen, an agent of lesser influence, is potentially able to affect both the ORF and PRF through its affiliation with more influential agents such as the Government, the DfE, and the Wellcome Trust. The nature of this affiliation can be linked to common ideologies surrounding the perceived importance of genomics knowledge to members of society. How Nowgen leverages these connections will be explored later (Chapter 8 Findings).

The determination that genomics knowledge is meant to supplement the Mendelian model in schools is influenced by several agents, many of which were also found on the field of production. The Government, Wellcome Trust, and Nowgen all have a measure of influence in determining how genomics is meant to be recontextualised to be taught to secondary students. The Wellcome Trust and Nowgen, specifically, held significant positioning on the PRF through the School Genomics Programme and its direct interactions with practicing teachers. This ability to influence teachers through indirect means plays a role in bringing genomics knowledge directly into schools through professional development and the creation of lesson plans.

These agents are joined by several others on the ORF as the process of curriculum revision brings in several new agents such as the DfE, secondary science teachers, science education academics, the learned societies (specifically the Royal Society of Biology then known as the Society of Biology), and the National Curriculum draft writers. Each would contribute to the revision of the 2011 National Curriculum and its development which would ultimately include references towards genomics. While each agent represents participation in the revision process, it is important to highlight the that it is unlikely each agent contributes equally or is even permitted to contribute equally. Table 7.4 does allude to a power structure in the process of revision.

Table 7.5 outlines these additional agents as identified from the data. Combining these agents with analysis from the field of production will be used to better illustrate the theorized network at play (9.3).

**Table 7.5. Agents Who Determined What Genomics Knowledge is Meant to Look Like for Secondary Students**

| Agent | Description |
|---|---|
| Government | The Conservative Government would initiate and oversee the 2010-2013 Revision of the National Curriculum which would result in the addition of genomics terminology to secondary science courses. |
| Genetic Knowledge Parks (Nowgen) | The Northwest Genetics Knowledge Park (Nowgen) would design and implement a professional development scheme based on introducing teachers to the teaching of inheritance through genomics and a multiple gene model along with some teaching resources to facilitate the process (Nowgen Schools Genomics Programme). As with the other Genetics Knowledge Parks Nowgen was managed by the Department of Health and worked with several partners in this. |
| The Wellcome Trust | The Wellcome Trust would provide Nowgen with additional funding to pursue their School Genomics Program. |
| Department for Education | The Department for Education is responsible for children's services and education, including early years, schools, higher and further education policy, apprenticeships and wider skills in England (DfE, 2021). Civil servants within the DfE would lead the 2010-2013 Revision with input from the Government and the Science National Curriculum Working Party. |
| Science National Curriculum Working Party (SNCWP) | The Science National Curriculum Working Party consisted of a group of individuals meant to consult the Government and Department for Education in revising the biology portion of the National Curriculum. This group would consist of *secondary science teachers*, *science education academics,* members of the *Royal Society of Biology,* and members of the *Nuffield Foundation*. |
| National Curriculum Draft Writers | These individuals would be charged by the Department for Education with drafting the revised National Curriculum based on input from the Government, Department for Education, and the Science National Curriculum Working Party. |

As with the previous analysis that centered on knowledge production and the processes that determine who is to receive it, there are revelations about how the movement of new knowledge from esoteric to the mundane was affected by the process of recontextualisation. The established distributive rules determine who is meant to receive newly produced knowledge by establishing the thinkable from the unthinkable and therefore what is suitable for teaching in school from what is not. Certain determinations about how the newly produced knowledge can be converted are also established by the distributive rules. Knowledge deemed thinkable but meant to maintain a semblance of specialist appeal may be more apt towards pedagogic recontextualisation while thinkable knowledge meant for non-specialist use may require further processes of recontextualisation past schooling. This idea connects the distribution rules established during processes of curriculum development with post-secondary efforts such as public engagement.

Determining secondary students as an audience for genomics knowledge establishes it as thinkable knowledge, but the determination that all secondary students require access to this knowledge moves it from specialist knowledge towards non-specialist knowledge, from esoteric towards mundane. Had it been determined that only secondary students seeking careers in medicine or genetics research were the target audience, then genomics knowledge would maintain its esoteric nature as it is being converted for potential specialist use. This occurrence may have allowed for a process of pedagogic recontextualisation focused on a smaller subset of teachers in specialist subjects only undertaken by a smaller group of students. Distributive rules based around all students requiring some aspects of genomics knowledge almost requires a process of recontextualisation that encompasses both the PRF and ORF. This finding has some implications for any pedagogic communication developed from the recontextualised knowledge.

### 7.3.3 Teaching and Assessing Genomics (Reproduction)

Pedagogic communication created through recontextualisation serves as a basis for the teaching and assessing of thinkable knowledge in schools. The process of teaching is carried out in schools with assessment being carried out by both teachers (in-class assessment) and state authorities (national exams). Bernstein refers to this as reproduction (Bernstein, 2004). Examining this aspect for the current study would be difficult as at the time of data collection, the teaching of genomics in secondary courses had just begun. However, the data does reveal some insight into the nature of how teachers determine the value of newly recontextualised genomics knowledge and the pedagogic communication developed from it.

It is important to note that the focus of the current study is examining the processes by which newly emerging knowledge is transformed into pedagogic communication such as curricula. Viewed through the lens of the fields of pedagogic device, these processes primarily lie in the fields of production and recontextualisation. To better examine the field of reproduction would require a study less focused on those agents participating in processes of curriculum development at the national level and one more so focused on those individuals who use curriculum as a basis for the development of lessons at the school level. While there is some of that aspect in the current case, specifically while discussing the Nowgen School Genomics Programme, this is seen more as an aspect of professional development for teachers rather than teachers carrying out a process themselves.

That said, there were some data points that broached concepts associated with the field of reproduction and the participants were able to speak to some of these conceptions. These instances came about from investigation of the research questions and while they do contribute to the study, they do not necessarily represent the basis of the study. It is important to point this out as this represent an opportunity for further study of the case in the future and do contribute to the current study in some regards. Table 7.6 outlines the key points along with sources of data used for this portion and some of the discrepancies amongst observations.

**Table 7.6 Points of Interest from the Field of Reproduction**

| **Key Observations (Timing)** | **Sources** | **Possible Discrepancies** | **Resolution** |
|---|---|---|---|
| Nowgen carries out research into teacher perceptions and understanding of genomics | Ginny W, Oliver W, Cedric D, Hannah A, Katie B<br><br>*Genomics in Schools: An Interim Report from the Nowgen Schools Genomics Programme* (2011)<br><br>*A Modern Education in School Science: A Manifesto for Change* (2012) | Key takeaways from the research that influenced the NSGP | Analysis of participant data reveals concepts such as teacher PD and experience affect perceived value of subjects |
| Release of Key Stages 3 and 4 of the Revised Curriculum | Dean T, Ginny W, Oliver W, Susan B, Katie B, Marietta E, Susan B, Hannah A<br><br>*Reforming the National Curriculum in England: Summary Report of the July to August 2013 Consultation on the Programmes of Study and Attainment Targets from September 2014* (2013)<br><br>*Science Programmes of Study Key Stages 3,4* (2013,2014) | Viewpoints on how changes to the curriculum were received by teachers | Participant data comparisons reveal a mixed response from teachers<br><br>Documentation and literature also reflect this |

#### *7.3.3.1 How might Teachers Determine the Value of Genomics Knowledge?*

As with previous fields, competition amongst agents is at the core of the field of reproduction. Here, agents vie for the ability to regulate what constitutes good practice in the teaching of genetics and genomics as well as establishing the criteria for valid acquisition of genomics knowledge in students. As mentioned previously, the current study was undertaken while the teaching of genomics, based on its entrance into the National Curriculum, had just begun, so the obtained data did not allow for exploring these aspects of reproduction. However, reproduction is also concerned with the criteria teachers use to determine the value of recontextualised knowledge to their students.

To explore the ideas of how teachers would determine the value of recontextualised genomics knowledge and pedagogic communication, portions of the data that spoke to how agents viewed the processes by which teachers take available recontextualised knowledge and pedagogic communication and make decisions about what is important to their students were coded. In this study, this coding pertains to utterances about how teachers decide what aspects of genomics knowledge in the National Curriculum and accompanying forms newly developed pedagogic communication they will focus their teaching on. Bernstein sees this as another process of *secondary recontextualisation* based on teacher perceptions of student needs (Bernstein, 2000; Singh, 2002). Although a process of recontextualisation results in the conversion of knowledge towards secondary students into pedagogic communication, teachers take the pedagogic communication and make determinations about what they themselves perceive students need to learn. This determination is often due to the sheer size of content teachers are asked to cover. Marietta E, an experienced secondary science teacher in London, speaks to this concern and how it affects the way she approaches teaching her students:

> "I think the GCSE specification is just far too big. Basically, the whole of GCSEs is you are trying to get through as much as you can every lesson because otherwise you just won't finish, which means that a lot of GCSE ends up being taught in a way that kids just have to learn stuff by heart to get through it so that they can pass the exam at the end. But you don't have time to play with ideas."
>
> Marietta E

Here Marietta E establishes that the amount of content can create limits to what and how teachers address science teaching. This, in turn, requires teachers to make decisions about how to prioritize their time with students and the expectations they have for their interacting with content. As such, the size of curriculum can play an incredibly important role in determining not only what teachers emphasize in the teaching, but also the processes they use to determine how they will maximize their time with students. This is by no means the only element that effects such processes, but it is important to note that it was highlighted by several participants, with each speaking to their level of experience and understanding of the matter. As such, utterances from the participants pertaining to how teachers make this prioritization were sought and coded for further analysis. This would help to further examine what the data revealed about the processes teachers use to make determinations about what they emphasize in their teaching. For example, Marietta E continues to discuss the aforementioned topic:

> "On a very simplistic level, in my teaching, I'm trying to do two things: One, help the kids to get the best possible grade in this exam because that's the hoop that has been put in front of us that we have to help them jump through so they can get onto the next stage. And especially in terms of social mobility. I've got to help my students to get those grades so they can get a position into a good university."
>
> Marietta E

To Marietta E, assessment *and* future prospects also help to determine how she will approach the teaching of her students. If she perceives the teaching of genomics to improve her students' future prospects, she will prioritize it. In a sense, this makes what is assessed in exams such as GCSEs and university entrance requirements a driving force in her prioritization in teaching the provided curriculum. This itself can be said to be a form of recontextualisation of the curriculum as the teacher uses their expertise and understanding to make determinations about what is most important to the student. This process of decision-making would be outlined by other participants discussing the ways that teachers determine how they will interpret the curriculum.

Oliver W also links this decision-making process in teachers to assessment, but also sees their personal familiarity as having influence. When describing how teachers consider their choice of resources provided by competing exam boards once pedagogic communication is altered, he states:

> "So if you change the content and you've got a bunch of teachers who are now going "what the hell is that new content" and you've got a competitor who is perhaps offering more familiar content then you might lose market share because teachers are free agents and they can go over from exam board A or exam board B because they prefer the content on example B and perhaps they're going to prefer a little bit of the content that is more familiar to them."
>
> Oliver W

Oliver W connects decision-making in teachers with what they are comfortable with. This consideration is in alignment with the previously established recontextualising rule emphasizing genomics knowledge that supplements the Mendelian model as opposed to replacing it. By supplementing existing content, you keep a certain familiarity that encourages teachers to consider new takes on what they have already been teaching. In this regard, the field of reproduction could have some effects on the field of recontextualisation. The data revealed more factors that affect the decisions teachers make surrounding new pedagogic communication. Teachers teach what exam boards examine, and when choices are made, they are based on what aligns with their preferences and experiences.

## 7.4 Summary

In this chapter I have outlined the processes used in applying Bernstein's Pedagogic Device to the collected data. This process led to the highlighting of some initial observations through which the aforementioned themes of relevance, substance, and transformation could be examined. In summary, the processes that led to the introduction of genomics knowledge into secondary science classes can be traced to desires to increase public engagement. Through analysis of the collected data, a network of organizations was identified as playing a crucial role these processes and there was a particular power structure that determined who could make what contributions. In the next chapters, I will explore these findings in the data and outline the narrative they reveal about how genomics came to be introduced into the National Curriculum.

# Chapter 8: Findings

As mentioned previously, the research questions of this study are focused on 1. How did genomics come to be the introduced into the National Curriculum and 2. What does that process reveal about the transformation of new scientific research into secondary science curricula and lessons. Analysis of data and documentation led to findings related to both how genomics knowledge came to be considered appropriate for secondary students and how it was to be converted into pedagogic communication. In this chapter, I will summarize these findings and the basis for them.

## 8.1 From Analysis to Findings

As outlined in Chapters 6 and 7, analysis of the data was based on both inductive and deductive coding processes. An initial process of inductive coding helped to develop some initial themes and questions. This would then lead to the development of more precise ways of coding and applying the pedagogic device to the data in search of observations in attempts to analyze the data to further explore these themes and questions to develop findings. Figure 8.1 outlines this process:

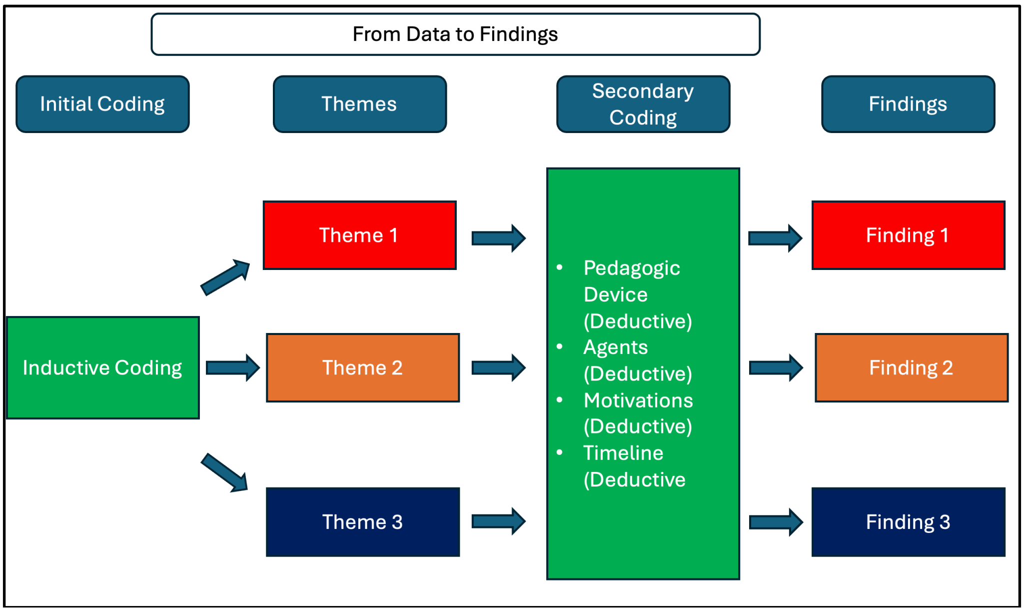


**Figure 8.1 The Development of Findings from Data**

As seen in Figure 8.1 and mentioned previously, three key themes came out of the initial process of inductive coding, each helping in exploring the study's research questions. Firstly, what was the exploration of the *relevance* of newly emerging genomics knowledge to secondary students? Secondly, what are the *substantive* aspects of genomics knowledge that secondary students need to be aware of? Finally, how was genomics knowledge meant to be *transformed* from a research discourse to one based on secondary science courses? As the goal of the study was exploring genomics and the National Curriculum in hopes of better understanding how new scientific developments become science curricula and lessons, each of these themes contribute to the exploration of the research questions and came with questions that needed further exploration. Who was responsible for making these decisions? What was the discourse surrounding them? Were there specific processes and how do these processes compare to other instances? The exploration of these themes would continue by viewing the data through the lens of Bernstein's Pedagogic Device.

Using the initial inductive coding schemes as basis, deductive coding schemes were created which led to both coding and analyzing the data through multiple lenses by exploring the initial themes of *relevance, substance*, and *transformation* involving genomics knowledge and secondary students through the application of the pedagogic device and the examination of those organizations and bodies involved in introducing genomics knowledge into the National Curriculum in addition to their motivations. Each round of coding was combined with processes of analyses, comparison, and contrasting of numerous sources of data in attempts to develop and explore the case for observations, themes, findings, and eventually conclusions.

As the initial round of coding provided a look into the data surrounding the case overall, each subsequent round of coding can be considered an exploration into those themes arising from the first round of coding. For example, utilizing aspects of data coded based upon the field of production, I was able to explore questions surrounding the theme of genomics knowledge and its relevance to secondary students. As the field of production is primarily concerned with the determination of suitable audiences for new knowledge, I was able to use the coding scheme from the application of this aspect of the pedagogic device to examine questions surrounding why genomics knowledge was deemed suitable for secondary students and why and how it came to be seen as relevant for them.

During exploration of this theme and the questions arising from it, I was able to compare participant responses to determine what each had experienced regarding this element of the study. As revealed previously, many participants made references to initial desires to increase public awareness as the completion of the Human Genome Project became imminent. This includes projects such as the creation of the Genetics Knowledge Parks. When delving deeper into the data concepts such as the potential of genomics knowledge to medical treatment and the need for greater understanding on behalf of the average citizen became clearer. Exploration of participant data and documentation helped in the development of findings through this process.

The themes of substance and transformation were also examined in this manner as utilization of coding schemes based on the fields of recontextualisation and reproduction. The coding scheme based on the field of recontextualisation was especially helpful in exploring these themes as recontextualisation primarily focuses on the processes that select and transform knowledge from one discourse to another. Each process of examination of those themes through questions and the analysis of data employing the coding schemes. Table 8.1 outlines what was explored in addition to how the subsequent processes of coding led to their exploration and the development of findings.

**Table 8.1 Development of Themes and Findings**

| ***Theme*** | ***Questions*** | ***Findings*** | ***Coding Schemes*** | ***Sources*** |
|---|---|---|---|---|
| The relevance of Genomics Knowledge to Secondary Students | *Did secondary students need genomics knowledge?<br><br>*How was this determined?<br><br>*What was the criteria?<br><br>*Who makes these decisions? | Sec. students require genomics knowledge because of potential medical application later in life. This is determined through collaborative processes involving public and private organizations in a bid to increase genomics awareness amongst the public in general. | PD<br>AG<br>MO<br>TL | Participant data from OW, CD, KB, GW, and HA<br><br>Docs from DoH, Nowgen, HoL |
| What do Secondary Students need to know about Genomics? (Substance) | *What do secondary students need to understand about genomics?<br><br>*How is this different from the current teaching of genetics?<br><br>*Can teachers reasonably present new genomics ideas to students?<br><br>*How are these questions answered and by whom? | It was determined students needed to understand the multiple gene model of expression as opposed to just learning the single gene model. This is initially the purview of Nowgen and its Schools Genomics Programme but is eventually incorporated into the National Curriculum during the 2010-2013 Revision processes initiated by a Conservative Government in coalition with the Liberal Democrats. The working party put together during this process determined the extent of its presence in the new curriculum. | PD<br>AG<br>MO<br>TL | Participant data from SB, ME, DT, OW, CD, GW, HA, ME<br><br>Docs from Nowgen, DfE, DoH, |
| The Transformation of Genomics Knowledge for Secondary Courses | *What does the current case reveal about the processes that transform new knowledge into pedagogic communication?<br><br>*Does this reveal anything about the pedagogic device? | The power structure involved in the current case is one where power is distributed from the powerful as opposed to wielded by the powerful leading to more processes that can be conceived as a more collaborative recontextualisation and curriculum development. | PD<br>AG<br>MO<br>TL | Participant data from SB, ME, DT, OW, CD, KB, GW, HA<br><br>Docs from Nowgen, DfE, DoH, Wellcome Trust, |
| ***Coding Scheme Key: II-Initial Inductive, PD-Pedagogic Device, AG-Agents, MO-Agent Motivations, TL-Timeline*** | | | | |

Each of the aforementioned themes contributed to the exploration of the research questions. Each of the themes speaks to the processes that led to the determination that genomics knowledge was actually relevant to secondary students and needed to play a larger role in the curriculum. The third theme specifically speaks to the ways in which genomics knowledge would need to be transformed from a research-based discourse to one more appropriate for secondary science students and how that process impacts the creation of curricula and lessons.

As evidenced by Table 8.1, the initial themes gave rise to questions that would be furthered explored through more utilization of the coding schemes applied the data. This included involving aspects of the pedagogic device, agents involved in the case, and a timeline of events. It is the exploration of these themes and questions that forms the basis of the findings presented in this chapter.

Exploration of these themes led to findings surrounding the organizations and bodies making these decisions and their motivations along with a general timeline of the events outlined. Examples of these processes were outlined previously (Tables 7.1 Basis for Findings on the Field of Production, 7.3 Basis for Findings on the Field of Reproduction, and 7.6 Basis for Findings on the Field of Reproduction). Combined explorations of these themes and coding schemes led to some initial findings outlined in sections 7.3.1.3 Initial Findings and Implications for Subsequent Fields (Production), 7.3.2.3 Initial Findings and Implications for Subsequent Fields (Recontextualisation), and 7.3.3.1 How Might Teachers Determine the Value of Genomics Knowledge. This consistent process of the exploration of Themes leading to the development of Findings forms the basis for what is presented here.

Of course, this process of examining the data for themes and questions leading to findings is not one without conflict. While there is often consensus and agreement amongst participant data and documentation, the exploration of each theme and the questions that encompass it do bring some levels of dispute and discrepancy. Previously in Section 7.3, I gave an overview of how discrepancies in the data were viewed and resolved in applying the pedagogic device. Here I would like to pay closer attention to how discrepancies were resolved in terms of the determination of findings based on what was revealed in by the data.

As stated previously, dispute amongst data sources was resolved through comparison with further data resources and documentation in an effort to reach consensus. As participants were asked about their specific experiences with the case, this meant making comparisons between individual participant data sets in addition to making comparisons of participant data to available documentation and literature. Upon review, findings were developed based on the consensus of available data, documentation, and literature. A good example of this is Table 7.4 National Curriculum Revision Agents and Power.

What is described in this chapter are the results of those processes. The findings outlined below were developed from processes of coding and analysis outlined in previous chapters along with legitimate attempts to develop a consensus on events through the review of both participant data, documentation, and literature. A review of Table 7.4 2011 National Curriculum Revision Agents and Power helps to illustrate this process.

As Table 7.4 illustrates, the data set of each participant was examined to make determinations on how they viewed the power structure of the 2010-2013 Revision to the National Curriculum. Amongst participants there was general agreement concerning the power of the Conservative and Liberal Democrat Government and the civil servants of the Department for Education at the top of this power structure and the role of

Secondary Teachers and members of Educational Academia as consultants but when exploring the role of other participants within Revision process things get murkier.

There are numerous disputes regarding the amount of power and influence wielded by groups such as the Wellcome Trust and Nowgen. These disputes even extend to the Draft Writer of the National Curriculum. While some participants report the Wellcome Trust as wielding a level of significant influence and power, others report differently. While some saw the Drafter as having power commensurate with the Government and Department for Education, others saw them as more consultant.

To reach findings on these multiple viewpoints, other data points were sought out. In the case of the Wellcome Trust, the majority of participants reported them as having influence on par with the consulting Secondary Teachers and Educational Academics during the process. Comparison of data from the outlier data sets with the data sets from those in agreement yielded greater consensus towards their status as a having some influence but not the most influence. This was also how findings were reached regarding the influence of the Drafter of the National Curriculum.

Other disputes amongst the data were handled in a similar fashion. In situations where participant data did not lean towards consensus, additional documentation and literature were used to make a determination. While these findings are reported, the discrepancies are noted when appropriate.

## 8.2 A Brief Summary of Findings

As discussed in 7.3.1.3, data suggests that it was initially determined that students studying for careers in medical fields would benefit from genomics knowledge because of its potential medical application (DoH, 2003). This recognition would eventually lead to the determination that all students would benefit from exposure to genomics knowledge as potential consumers of future genomics-based healthcare.

As revealed by analysis of participant data and documentation, agents involved in this process included both the Labour Government and the subsequent Coalition Government (between the Conservative and Liberal Democratic parties), the DoH, the Genetics Knowledge Parks, and the Wellcome Trust (DoH, 2008). When viewed through the pedagogic device, the determination of secondary students as a suitable audience for genomics knowledge represents the establishment of a distributive rule, rules that dictate who is meant to receive new knowledge. As the focus of the first research question of the study focuses on how genomics knowledge came to be introduced into the National Curriculum, this revelation is highly significant.

Upon determination that secondary students were a suitable audience for genomics knowledge, that knowledge undergoes a process of conversion towards pedagogic communication appropriate for its new audience (recontextualisation) (Singh, 2017). Based on participant reporting, it can be inferred the recontextualisation of genomics knowledge primarily occurring through two paths. Firstly, there was the Nowgen Schools Genomics Programme. Developed by Nowgen in conjugation with other organizations and funded by the Wellcome Trust, the Nowgen Schools Genomics Programme created both teacher resources and professional development opportunities to instruct teachers on how to integrate genomics knowledge into their lessons.

Secondly, there was the 2010-2013 Revision to the National Curriculum which represented the opportunity to introduce genomics language into the National Curriculum for England's Science PoS (DfE, 2013 & 2014), which serves as a basis for the creation of teaching resources and examination specifications. Initiated by the

Conservative Government, at the time in coalition with the Liberal Democrats, this process would see the Department for Education bring together a working group of secondary science teachers, science education academics, and others with expertise in the fields of science and curriculum to revise the biology, chemistry, and physics portions of the National Curriculum for England. During this process members of the working party would regularly meet to discuss what scientific knowledge secondary students needed to know before leaving school. The exploration of this process played a significant role in examining the second research question and its focus on the processes that transform science research into secondary science curricula and lessons.

Based on analysis of data, both processes of converting genomics knowledge for secondary students centered on whether that knowledge was meant to replace the teaching of the classical, Mendelian model of teaching inheritance or meant to supplement it. Eventually, both processes would concentrate on genomics knowledge supplementing the widely taught Mendelian model of inheritance.

As discussed previously, several organizations were involved in the process of converting genomics knowledge, such as the Government, the DfE, the Wellcome Trust, the Royal Society of Biology, members of both education and science academia, and secondary teachers (Chapter 7 Analysis).

Upon its conversion into teacher resources and curriculum documents, genomics knowledge then undergoes a second process of recontextualisation by teachers. Teachers take resources and curriculum documents and make determinations about what to teach based on what is perceived valuable to their students. This determination is often based on student needs such as future prospects and exam specifications or teacher comfort (Chapter 7 Analysis).

## 8.3 Genomics from Research Labs to Secondary Science Courses

As previously outlined, the introduction of genomics knowledge into the National Curriculum can be traced back to the Human Genome Project (HGP) and its potential impact on human medicine. As the conclusion of the project drew nearer, the Labour Government established the Genetics Knowledge Parks (DoH, 2003, 2008, 2021). These organizations were meant to represent a collaborative approach amongst public and private organizations to integrate the newly emerging genetics and genomics knowledge into the everyday lives of the British public. The Genetics Knowledge Parks would represent cooperative efforts between government departments, private research organizations, universities, and others in developing ways to utilize the newly emerging knowledge and increase public awareness. The establishment of the Genetics Knowledge Parks would establish working partnerships that could be used to further genetics research initiatives through collaboration amongst numerous stakeholders.

In a sense, the establishment of the Genetics Knowledge Parks represents a collaborative effort between the government and non-governmental organizations to alter culture and societal views surrounding the role of genetics and genomics knowledge in healthcare and medicine (DoH, 2008). The United Kingdom had contributed significant investment into the mapping of the human genome and similar genomics research endeavors. Nearing its conclusion, the HGP represented a potential return on investment in the form of genomics-based medicine, but a society that places little cultural or practical value on this knowledge is unlikely to embrace or interact with its development. Understanding this dilemma, the Genetics Knowledge Parks worked to better integrate the developing knowledge into the lives of the public, thereby creating a new culture surrounding genomics-based medicine (DoH, 2008). The DoH would work with organizations such as the Wellcome Trust in developing ways to bridge the gap between current knowledge and what was to come (Bonn, 2005; Robertson, 2007).

Affecting culture this way is consistent with the pedagogical device (Bernstein, 2000). On the field of production, the powerful are often able to achieve their means by consolidating the field through establishing what is considered to be "normal" behavior (Singh, 2002). By establishing that genomics knowledge should be valuable to public, the government begin to establish what can be called the "position of the powerful". This determination represents the first steps towards establishing the distribution rules (Bernstein, 2001a). As the government makes its position known, the less powerful seek to find alignment and in doing so "adjusts" their views. This phenomena reveals how society is shaped by the powerful agents' control of knowledge dissemination (Bernstein, 2004).

One of the Genetics Knowledge Parks, the Northwest Genetics Knowledge Park (Nowgen) held a remit of public engagement (Nowgen, 2012; Robertson, 2007). Initially, their goal was to increase public engagement as a means of preparing the public to interact with the potential advancement genomics research would provide in medicine and healthcare. Consisting of individuals working within the public, private, and volunteer sectors in organizations such as the DoH, universities, and the learned societies, Nowgen would work to establish ways to increase public knowledge and awareness of genomics and its potential impact on their daily lives. This work would help create a public impression of genomics testing as non-threatening and potentially helpful. To accomplish this task, Nowgen published and circulated literature throughout England and worked with media companies to create opportunities to spread this message.

While these initiatives were ongoing, a determination is made that while informing the public was an important pursuit, greater utilization of genomics-based medicine would also require greater amounts of knowledge in those working in the healthcare profession and their training to become healthcare professionals. This determination would lead to intentional efforts to provide training for individuals currently working within healthcare and more intentional study of genomics for students in universities working towards degrees and potential careers in healthcare.

Here the first connections with changing public awareness in genomics through altering education can be seen. The shift from the general public to students of healthcare and healthcare professionals is a logical step. Although changing public sentiment around genetics and genomics medicine can be achieved, it is ultimately those individuals working in healthcare who often interpret and help to recontextualize medical information for those receiving treatment (the public). While increasing public awareness could help increase public interaction with genomics medicine, without healthcare professionals playing a key role in recontextualising this information, the knowledge could ultimately be lost in the arena where it is most important (Cooper & Psaty, 2003; Feero & Guttmacher, 2014). This changing of genomics culture in society though education begins as a subtle shift at the higher education level amongst a small, targeted group of students (Strachan et al., 2014).

As previously established (Chapter 2), curricula can be viewed as the aspects of knowledge and culture deemed appropriate for members of society (Kelly, 2009; Klein, 1992). The creation of curriculum represents intentional decision-making in determining what members of society should know and possibly value. While there was an ongoing effort to establish a public culture around genomics, attempts to accomplish this task through secondary school education would come later, and higher education would be first prioritized. As such, the desire to alter culture is the result of a top-down process where those in power attempt to impose a new culture on society as opposed to society determining what aspects of culture are appropriate for socialization.

As the need for increasing genomics knowledge amongst those preparing for and currently working in healthcare was apparent, there was also a growing need for understanding amongst those most likely to truly take advantage of the potential of genomics-based medicine. Having already invested in raising awareness in the general public and healthcare professionals, Nowgen would then set their sights on the next generation. Continuing their work with the government and securing funding from the Wellcome Trust, Nowgen developed the Nowgen Schools Genomics Programme (NSGP) in an effort to increase awareness of genomics knowledge in secondary schools by providing professional learning opportunities for secondary science teachers (Nowgen, 2012). Through the development of lessons, videos, labs, and trainings, NSGP would help to raise the secondary science teachers' level of understanding in genomics in addition to providing direct practices on integrating elements of genomics into their teaching of inheritance and genetics. This initiative includes the development of professional development opportunities that focused particularly on teaching genomics as well as laboratory experiences that directly showed students the potential of genomics research. Partnering with educational organizations such as the Nuffield Foundation and genetics research centers such as the Sanger Institute, NSGP created a direct opportunity for Nowgen to work with teachers in introducing elements of genomics knowledge to secondary science students. This opportunity continued their goal of developing greater understanding within the public as more students taught the new knowledge leave school.

As NSGP continued, another opportunity arose in the form of the 2010-2013 Revision to the National Curriculum for England. In 2011 the Coalition Government, embarked upon revising the National Curriculum for England, including the sciences. This process would see the DfE, under the guidance of the Government, bringing together numerous stakeholders in efforts to revise the National Curriculum (DfE, 2013b). In compliance with this directive, the DfE convened the Science National Curriculum Working Party. This collection of science teachers, science education academics, members of the learned societies (specifically the Royal Society of Biology then called the Society of Biology), and members of educational organizations such as the Nuffield Foundation, would act as experts advising the DfE in its development of a new science curriculum. It was in this capacity that Nowgen was invited to participate in the revision of the curriculum at the behest of the Government.

This process would have its difficulties. It was apparent from the beginning that the Government placed an emphasis on a curriculum "strong in knowledge". This curricular preference was seen as a shift away from the previous curriculum which emphasized science as a process in addition to a collection of knowledge.

There are also questions about the power structure of those participating in the process. While data reported that both Government and the DfE held the greatest amount of influence throughout the revision process and that Secondary Science Teachers and Education Academics also wielded significant influence, there were questions about the role of organizations such as the Wellcome Trust and Nowgen. While the Wellcome Trust itself did not have a direct representative on the SNCWP, it can be said they were indirectly represented by organizations and individuals with their affiliation. Similar questions arose concerning the role of the Drafter of the National Curriculum.

Questions surrounding the nature of genetics teaching arose during this period. At the time, the Classical Model of Mendelian genetics dominated the teaching of inheritance in secondary schools. Making alterations to this teaching paradigm would require some efforts. Questions were asked about the appropriateness of the Classical Model in preparing students to interact with modern advancements in genetics. Of great relevance to this debate was whether it was more important for students to have an understanding of the foundational Classical Model of inheritance and its emphasis on single gene disorders or for them to be well versed in recent advancements in genomics which could potentially play a key role in the medical treatment students may receive in the future. There were also questions surrounding which of the two perspectives more appropriately prepared secondary students for careers in genetics research or healthcare. Ultimately it was determined that some integration of genomics knowledge was necessary to prepare students for future interactions with genetics information and minor changes were made to the National Curriculum.

As the SNCWP struggled to develop a curriculum which satisfied the Government's direction, a drafter was brought in to consolidate what was coming out of the working party's meetings into a singular curriculum that could be reviewed first by the DfE and then by ministers. As stated previously, there were questions about the amount of influence and power the Drafter wielded throughout the process. Some participants reported the Drafter as having the ability to gatekeep certain aspects of the curriculum as they had more frequent contact with the DfE throughout the process while others reported them as having influence more on par with the Secondary Science Teachers and Science Education Academics. While both points of view are valid, the consensus of the data obtained outlined a viewpoint that stated the drafter yielded greater influence than that of Secondary Teachers and Education Academics and through the continued process of deliberation and revision the current National Curriculum was developed. What is revealed here is a process of curriculum development that includes far more agents than in the past, creating what can be seen as the illusion of far more collaborative processes but with a very familiar power structure.

### 8.3 Summary

This study was focused on exploring research questions surrounding both the introduction of genomics into the National Curriculum and what that process may reveal about how scientific research become secondary science curricula and lessons. In this chapter, I have outlined what was revealed from the analysis of the data. There were some important discoveries while exploring the introduction of genomics into the National Curriculum. In the next chapters, I will look at what this process reveals in terms of the practical creation of curriculum as a process of policymaking, the argument surrounding introducing more modern research elements into current genetics teaching, and what the case reveals about the theoretical approach to studying how new knowledge becomes what is taught in secondary science courses.

## Chapter 9: Discussion

This study is one of the first to explore the ways in which different agents, motivations, and social structures influence the development of curriculum, through the lens of a case study on the introduction of genomics into secondary science courses. Through the collection and analysis of a range of data, I was able to uncover some insights into the research questions:

1. *How did genomics come to be introduced into the National Curriculum and secondary science courses in England?*
2. *What does this reveal about the processes that select and transform newly developed knowledge into curriculum and lessons in secondary science courses?*

The current case covers a period of roughly 2002 through the publishing of the 2014 National Curriculum for England PoS and its implementation in 2016. There are links to several organizations and processes which required specific processes of data collection and analysis. As previously outlined, participants with professional backgrounds and experience with development of pedagogic communication regarding genetics and genomics were sought out to explore the research questions. Each participant underwent a semi-structured interview as a means of collecting data. While each participant did have some experience with the development of pedagogic communication regarding genetics and genomics in the form of teaching materials or curricula, the participant pool does represent a sample of individuals with expertise within the subject matter and case along with a great diversity of professional experience. Semi-structured interviews allowed for each participant to expound on the case in their own way without restricting their responses. Questioning and analysis focused on the experiences of the participants while there were times inquiries about their perceptions of processes and agents were sought out for clarity. As stated previously, many of these decisions are based on the desire to focus on the process of curriculum development as opposed to the curriculum as a product often outlined in literature.

The data collected then underwent a process of inductive coding to determine some preliminary themes and questions surrounding the case. This process also helped to establish processes of deductive coding to continue exploring the themes through the lens of Bernstein's Pedagogic Device in attempts of investigating the research questions. From these processes of data collection and analysis some findings were discovered.

Regarding the first research question, the eventual addition of genomics knowledge to the National Curriculum for England can be linked to desires to increase its public awareness (7.3 Applying the Pedagogic Device to the Data). This desire to increase the public awareness of genomics through secondary science courses was the result of interactions between several English governmental departments, individuals within the teaching profession, and some private organizations, each with at least some alignment of goals regarding the role of genomics knowledge in society (Analysis 7.3 Applying the Pedagogic Device to the Data).

Several organizations would play a role in contributing to the recontextualisation of genomics knowledge towards secondary science courses. These organizations include the Government, the Department of Health (DoH), the Department for Education (DfE), the Wellcome Trust, the Nuffield Foundation, the Northwest Genetics Knowledge Park (Nowgen), the learned societies (specifically, the Royal Society of Biology), and others. Each played a role in attempting to expand the scope and reach of genomics knowledge in order to recontextualize some aspects of it to develop non-specialist understanding for a new audience.

In previous chapters, I examined the role of curriculum as a process of socialization often influenced by culture (2.2 Curriculum, Culture, and Society) and the policy processes that encompass its development (2.3 Curriculum Development as Education Policy Making). In this chapter, I will review what the case of genomics reveals about these ideas.

Regarding the second research question, the case of genomics reveals how those in power use curriculum to determine what is appropriate for teaching and worthy of recontextualization. This outlines what is deemed appropriate to be taught in schools and therefore meant to be of value to society. The current case outlines a view of recontextualisation that emphasizes knowledge considered valuable to society by government and those with aligning interests. The value attached in the specific case of the recontextualisation of genomics can be tied laying a foundation for the potential application of knowledge procured in genomics research endeavors such as the Human Genome Project. While this motivation creates an atmosphere amenable to the inclusion of genomics into the National Curriculum, it is not the specific process that led to its eventual inclusion. Concentrating on the processes that led up to the 2010-2013 Revision as well as the Revision process itself, helped to reveal some insights into the forces that determine and transform new knowledge into pedagogic communication.

Curriculum can be seen as the knowledge deemed appropriate for members of society and the case of genomics sheds some light on who is making that determination. As outlined previously, many factors can enable and limit curriculum development processes and the current case reveals a few things about the processes that drive the knowledge recontextualisation. In addition, it explores how the development of curriculum is often based on the needs of society as perceived by the powerful and ideas are passed from the powerful to the rest of society.

## 9.1 The Recontextualisation of Genomics: Power Structures

The introduction of genomics into the National Curriculum can be seen as product of the interactions of several organizations. As stated previously (Table 7.4), several participants reported a top-down process of revision led by the DfE and driven by the Government. Drafters would eventually play a big role collecting and organizing what came out of collaborative meetings into curriculum documents that could be presented to the DfE and ministers while secondary science teachers and science education academics also made key contributions in terms of outlining the specific topics and the reasonable depths of learning expected from students. Organizations such as the Wellcome Trust and the Society of Biology also had influence through their interactions with members of the SNCWP. At the lower end of the structure of influence is Nowgen.

This power structure is not entirely unexpected. Governments often lead policy processes through directives to the civil service working in specific departments (Loer, 2020; Sonia, 2021; Weinberg, 2021). The process of consulting experts and even members of the public to assist with the development of policy is also quite ordinary (Burch et al., 2005; Dorfman et al., 2010; Purdam & Crisp, 2009). As the purpose of the study was to explore the factors that led to the inclusion of genomics knowledge into the National Curriculum, there are some noteworthy aspects of this power structure. Firstly, there is the perceived lack of power on behalf of Nowgen. While Nowgen is rarely reported as wielding significant amounts of power during the revision to the National Curriculum, they are ultimately successful in seeing elements of genomics knowledge added to it. While Nowgen may not hold significant amounts of power themselves, their affiliations with much more powerful organizations lends them greater standing in the processes of consultation during revision.

Secondly, there is the impact of the Wellcome Trust on the 2010-2013 Revision. All participants reported the Wellcome Trust as having had a high level of impact on the revision process but unlike other organizations they did not have direct representation within the SNCWP or the DfE. According to Oliver W, contributor to Nowgen and member of the SNCWP, the Wellcome Trust specifically make no attempts to affect matters of curriculum development:

> "They funded Nowgen Schools Genomics Program because they put an awful lot of resources into genetics and genomics research. The Wellcome Trust Sanger Institute up in Cambridge is an enormous commitment from them and they recognize its value and I think it's fair to say the Nowgen Schools Genomics Program was funded and supported because of their broader interest in genetics and genomics. But within their education team they would not go after specific curriculum content. They would leave that to the Society of Biology."
>
> Oliver W

If this view of the Wellcome Trust is the case, how did they have such an impact on the revision process? Taking a deeper, more nuanced view of the power structure at play provides an opportunity to explore these questions and what they reveal about the teaching of contemporary science research in schools.

Power can have multiple forms in the context of the development of curriculum. Bernstein (2004) refers to power as both the ability to determine what aspects of knowledge are suitable for society and the ability to specifically create pedagogic communication and discourse based on those preferences. There is sometimes, but not always, overlap and it can be difficult to identify who wields which forms of power. For example, it can be inferred the Government driving the 2010-2013 Revision wields both the power to determine what aspects of emerging scientific research are suitable for society and what should be included in the National Curriculum and therefore taught in schools. This wide range of authority allows them to propagate the aspects of science they value through school experiences. Conversely an organization such as the DfE wields power in influencing the development of the National Curriculum but does so at the behest of the Government. They shape pedagogic communication and discourse, but often it is the government's views of societal needs that determine what ultimately constitutes the National Curriculum and, to a certain extent, what is meant to be taught in schools. In a sense, power flows from the government to those participating in the curriculum development processes and exploring how that power is transferred and dispersed helps to explain what may be happening.

### 9.1.1 The Distribution of Government Power

It cannot be denied that the government hold great influence on the curriculum development process and the final product, but I would posit that, in this case, power is more so *distributed* from the top than *wielded* by the top. By distributed, I mean to say that the power held by the government, while also used to directly affect the development of the National Curriculum, is most often distributed to other organizations and individuals rather than specifically imposed during the revision process.

In some cases, the distribution of power is the result of processes already in place such as the government initiating the revision with the DfE. In other cases, the distribution of power can stem from the needs or desires of the powerful. It can be argued that the recontextualisation of genomics knowledge towards secondary students is the result of power being distributed from the government to the DfE, the curriculum drafters, and specifically Nowgen. Participant Susan B, a contributor to the 2010-2013 Revision, alludes to this transference of power:

> "We within the side of biology, worked with the Wellcome Trust and people like that but actually they weren't particularly the people that the Government wanted us to listen to. They (Government) wanted us to listen to an organization called Nowgen who had a particular perspective on genetics and genomics which we were directed to listen to."
>
> Susan B

The government does not specifically tell the SNCWP what to include in the curriculum but does steer them towards Nowgen for guidance on genetics and inheritance. This arrangement is not surprising as the Coalition Government between the Conservative and Liberal Democrat parties continued to support public engagement in genomics knowledge originated by the Labour Government. This places the government and Nowgen and in alignment as both see mutual benefits to a society more understanding of genomics knowledge. Nowgen uses this distributed power as an opportunity to pursue their goal of seeing genomics knowledge introduced into the National Curriculum. These interactions start to explain why an organization with little perceived power is able to have such large impact. The 2010-2013 Revision is actually the second time Nowgen would be afforded this opportunity as they had also been given an opportunity to work on the Revision of the Scottish Curriculum for Excellence prior. Both opportunities come out of their affiliation with more powerful institutions and organizations (the Wellcome Trust during the development of the Scottish Curriculum for Excellence and the Coalition Government during the 2010-2013 Revision).

The current case does reveal some aspects about the nature of the relationships between government, science curriculum, and society. Coll and Taylor (2012) outline a view that governments should form science curricula based on a combination of societal needs and past and potential local experiences. This viewpoint requires the expertise of those outside of government, but the current case reveals that high priority is placed on experts that align with government interests. This occurrence contrasts with other views such as Uljens and Rajakaltio (2017). Their study of the development of the National Curriculum in Finland outlined a process characterized by efforts to build political consensus and autonomy for educational administration. In the current case, it appears as if the Government tried to achieve both ends through endorsing Nowgen and encouraging their participation in the development process. By promoting Nowgen to the SNCWP, they get the opportunity to have their positions argued while not specifically directing the process. This could be seen as an attempt to create some autonomy within the SNCWP, although it is hard to argue that was the way it was interpreted. In some ways, this occurrence mirrors Harris-Hart's findings on the Australian government's attempts to develop a National Curriculum (Harris-Hart, 2010). The study found the Australian Government's numerous attempts at intergovernmental collaboration less a form of co-operative federalism, governing based on giving more policy influence to non-government expertise, and more in line with coercive federalism, governing through the development of private-public relationships meant to create the illusion of collaboration while primarily furthering government stances.

### 9.1.2 The Distribution of the Power of the Wellcome Trust

Nowgen also benefits from power distributed from other organizations. The relationship between Nowgen and the Wellcome Trust was outlined previously (7.2.2 Converting Genomics Knowledge to Pedagogic Communication). The Nowgen Schools Genomics Programme was established through a partnership with the Wellcome Trust to develop professional development and course materials to assist secondary science teachers in introducing their students to genomics knowledge. Wellcome's funding of the project suggests some level of alignment in goals. Through their funding of NSGP, the Wellcome Trust distributes their power to Nowgen although in a different setting. Nowgen then brings this distributed power to the revision process as they become participants in the SNCWP, of which they are invited to by another powerful organization (the Government).

This power structure reveals a situation in which the Wellcome Trust uses it funding and support schemes to impact, not only the processes of professional development and teacher training (NSGP), but also processes such as the 2011 Curriculum Revision. Considered through the lens of the pedagogic device, they affect the Pedagogic Recontextualizing Field through direct influence and power and the Official Recontextualizing Field through the distribution of influence and power to others.

The relationship between government and non-government organizations in the development of education is well documented (Gearon, 2006; Hahn, 2015; Mannion et al., 2011; Marshall, 2005). This relationship is one typically rooted in policymaking aspects and the current case adds to that in some regards.

### 9.1.3 A Network of Genomics Recontextualisers

Nowgen is able to exceed its perceived positioning due to the power distributed to it from more powerful institutions. Having been established and supported by multiple governments, the Department for Education, and the Wellcome Trust, Nowgen is afforded numerous opportunities to contribute to the curriculum revision processes. This is not entirely surprising, as it is possibly the kind of collaboration between government and non-government organizations outlined in *Our Inheritance, Our Future* (DoH, 2003). In essence, these organizations and institutions constitute a network of alignment with significant overlap in the specific goal of broadening the understanding of genomics knowledge.

In employing this approach, the government, DoH, Nowgen, and the Wellcome Trust attempt to create a level of genomics understanding for non-specialist use (the public interacting with genomics medicine) while preparing future genomic scientists. They are attempting to build a culture surrounding recontextualisation of genomics knowledge. When considering this revelation through the pedagogic device, we can start to see the role government plays in using recontextualisation to alter societal viewpoints through the conversion of the esoteric, in this case, genomics knowledge, to the mundane, everyday layperson's knowledge. By developing and controlling non-specialist use of genomics knowledge, agents in power can create and alter culture based on their perceived values. According to Bernstein they seek to determine what knowledge is appropriate for the public (distributive rules) and in doing so determine what knowledge is both suitable and valuable (Bernstein, 2004; Bourdieu, 1990b).

This idea of the powerful using the distribution of knowledge is consistent with Bernstein's and others views of the pedagogic device (Bernstein, 2000; Singh, 2002; Wheelahan, 2005). However, there are some distinct differences in this case. While the powerful often use the distributive rules as a means of passing on their societal values to the less powerful, this is typically done by distributing different forms of knowledge to different groups. This is often the result of delineating thinkable knowledge, knowledge taught in schools, from the unthinkable, knowledge that is obtained outside schools (Wright & Froehlich, 2009). By concentrating on the distribution of knowledge to the public at large, and then shifting to secondary science students and extending the reach of genomics knowledge, the powerful, in this case the government and the Wellcome Trust, attempt to make genomics knowledge more widely available as opposed to restricting it. This use of governmental power reflects the use of production-reproduction systems to incorporate ideas into society through the interactions of pedagogic communication, teachers, and students (Bernstein, 2000; Singh, 2017). This outcome approaches what Bernstein characterized in his later writings as the "totally pedagogised society" where the relationship between society and the government is based more so on policy centered on consent as well as coercion, or pedagogic governance (Bernstein, 2001b; Singh, 2017). In this study government is seen working with non-governmental organizations in attempts to engage the public with non-specialist forms of genomics knowledge. The result of these interactions is a process of curriculum development where power is distributed as opposed to wielded.

In some ways, the distribution of power involved in this case could be reflective of the creation of pedagogic communication through policy networking (Ball & Exley, 2010). Described by Rhodes as a process of governing through interorganizational connections, the idea of policy networks leading to policy creation is not a new one (Rhodes, 1990). If a policy network is at play here, it likely most closely aligns with that conceived by Stephen Ball (Ball, 2008). Ball sees the idea of policy networks as a form of governance and policymaking that brings new kinds of actors into the policy process, enabling new forms of policy influence and hierarchies. He sees this process of policymaking as less government centered and more polycentric, with policy being created through multiple agencies and multiple sites of discourse generation (Ball & Exley, 2010).

Of course, this particular process was very government-centered but did allow allies of the government to influence the final outcomes as both Wellcome Trust and Nowgen both used their standing to participate in both processes of knowledge production (determination of the appropriate audience for genomics knowledge) and knowledge recontextualisation (the conversion of genomics for the aforementioned appropriate audiences). This outcome could explain how the less powerful Nowgen, holding aligning ideologies with the more powerful government and Wellcome Trust, obtained their support leading to the development of the Nowgen Schools Genomics Programme and their participation in the revisions to the Scottish Curriculum for Excellence and the National Curriculum for England. It is also possible the Government distributed their power to others as well.

At different levels of decision making, various agents select the “what” and “how” of curricular content. Pedagogic discourse, therefore, is affected by ideology and is never neutral. Bernstein (2000) identified two separate forces in operation in the classroom, which he called instructional and regulative discourse, respectively. Instructional discourse creates tangible skills and knowledge within particular school subjects, whereas regulative discourse controls relations between all actors, creating social order and constructing identities. As this is the case, the powerful can distribute their power to others not only to consolidate more power but also to regulate their values and culture to maintain power. The current case can be said to be a reflection of this model.

### 9.1.4 The Effects of Distributed Power on Curriculum Development

The same power structures that determined genomics knowledge suitable for inclusion in the National Curriculum also contributed to its recontextualisation towards secondary science courses. At various levels of decision making, various agents interacted to determine curricular content. Agents participating in this decision making brought their own experiences and ideologies (tastes) to the discussion. While the model of distributed power outlined above favors those agents who share ideologies with the powerful, there are still opportunities for the less powerful to influence the processes that determine the form knowledge will take.

Analysis of the data revealed the recontextualisation of genomics knowledge occurred primarily through the creation of genomics-based lessons and professional learning opportunities through the development of the NSGP and through the 2010-2013 Revision of the National Curriculum. Both processes resulted in the transformation of genomics knowledge from research science to lessons appropriate for secondary science students. The NSGP was focused on direct work with science teachers while the revision process concentrated on policymaking. As stated previously, when viewed through the lens of the pedagogic device these approaches can be viewed as products of the pedagogic recontextualising field (private education groups and specialized media in education) and  the official recontextualising field (local and state government) (Bernstein, 1990).

Typically, members of the PRF struggle to control the processes that construct pedagogic communication such as curricula (Singh, 2002). The development of the National Curriculum is a state process and governments hold much greater control, although they often employ members of the PRF as consultants, as was the case during the 2010-2013 Revision. The distributed power structure detailed previously slightly changes the dynamics of the process as Nowgen employed the combined distributed power of the government and Wellcome Trust.

The introduction of genomics knowledge into the National Curriculum created several questions concerning its role in the teaching of inheritance. At the center of these discussions was whether genomics knowledge was meant to replace the current teaching of Classical/Mendelian Genetics or merely supplement it. This particular finding potentially reveals much about the factors that affect processes of both official and pedagogic recontextualisation, and the way distributed power is used by the less powerful.

The addition of genomics knowledge into the National Curriculum revealed a distributive power structure wherein the most powerful allocate their ability to influence the process of curriculum development to less powerful stakeholders with similarly aligned goals. This distribution of power creates an opportunity for less powerful stakeholders to contribute to the process of curriculum development, thereby giving them an opportunity to contribute to the processes that transform domain specific knowledge into a form of non-specialist knowledge (recontextualisation). Questions surrounding the role of genomics in the modern National Curriculum help to reveal how this distributed power structure affects the processes that modify knowledge for new audiences (recontextualisation rules).

How does this structure of distributed power affect the processes of curriculum development and the pedagogical communication that resulting from them? As noted previously (2.4 Curriculum Development as a Process of Human Agency), Bens et al. reveal four major factors that can limit curriculum development processes (Bens et al., 2021). These factors can be separated into two elements. Firstly, there are the Participant Factors, the make-up of the curriculum working group and their perceptions of the process and their role within it (Contexts and Culture/Educational Developer Contributions). Secondly there are the Process Factors, the processes the development working group employs to make determinations about what specific elements belong in the curriculum, how it should appear, and the precise language used to convey meaning and guidance (Structures and Resources, Attention and Focus).

Exploration of the data revealed some insights into how the SNCWP may have been affected by Participant Factors. As previously reported, membership of the SNCWP certainly reflected a number of different stakeholder perspectives and study participants reported the group holding a clearly defined role as consultant to the DfE and the Government. The power was reported as being primarily held by the government and the DfE, which is no surprise as the SNCWP are employed as consultants. In a sense, analysis of the data reveals a process of curriculum development consistent with those outlined in literature (Baldock et al., 2013; Bates et al., 2011; Trowler, 2003).

The fact that this power structure is familiar does not make it ideal. While the nature of distributing power in this way does create the opportunity for new actors to influence and contribute to the creation of official pedagogic communication, this may only be true for those organizations with viewpoints in alignment to the already powerful. This means that the powerful could use distributive power as a means of creating the illusion of collaborative curriculum development while seemingly using others to reinforce their values on knowledge.

The distribution of power in this case can be viewed through this lens. The government specifically instructed the SNCWP to consult with Nowgen during the 2010-2013 Revision. Nowgen, having already contributed to the development of the Scottish Curriculum for Excellence, recognized another opportunity to introduce genomics knowledge into a taught and assessed curriculum. Both the government and Nowgen got the opportunity to see their shared goal of increasing genomics knowledge through the secondary schools come to greater fruition. This outcome does lead to some probing questions. If the government have the power to guide the work of the SNCWP, why go through the process of bringing in another organization to make the argument within the SNCWP? The answer lies within the process itself and the aforementioned Participant Factors.

By distributing power to a lesser organization, the Government driving the revision process is able to distance itself from the consultation and preserve the impression of collaboration. This arrangement allows for the powerful to continue to control the distribution of knowledge while bringing more allies into the process. For the powerful, this arrangement increases their sphere of influence adding new allies to the curriculum development process. New agents gain access to curriculum development.

The recontextualisation of genomics knowledge towards secondary science courses can be also considered through the previously mentioned Process Factors. The data reveals that both the development of the NSGP and the 2010-2013 Revision to the

National Curriculum were both influenced by the social, cultural, and political landscapes of the times. As revealed by the data, the decision to incorporate more elements of genomics knowledge into secondary science courses can be traced to interactions between the multiple governments, government agencies such as the DoH and the DfE, and the Wellcome Trust. The Wellcome Trust partner with the DoH to fund the NSGP and its remit of increasing genomics knowledge amongst secondary science students by creating professional learning opportunities for secondary science teachers. This partnership then forms the basis for the inclusion of Nowgen in the SNCWP during the 2010-2013 Revision. As such, the SNCWP and its make-up of multiple stakeholders plays very little role in determining what specifically belongs in the curriculum.

While more powerful agents such as the government and DfE determine the inclusion of genomics knowledge into the National Curriculum (distributive rules), the SNCWP play a significant role in the extent to which genomics knowledge is included and the role it is meant to play in the life of the learner. It is in these discussions where elements of the Process Factors can be considered. The data outlines specific conflict amongst the SNCWP surrounding whether the inclusion of genomics is meant to replace the then currently taught model of Classical Genetics or supplement it.

This distributed power structure would seem to have effects on the aforementioned Participant Factors. As stated previously, ideal curriculum development is often described as collaborative and reflective of the viewpoints of many stakeholders (2.4). The distribution of power from some agents to others would seem to create a more collaborative structure while also limiting the reflected viewpoints of the stakeholders. This could have the effect of bringing more voices to the curriculum development process while possibly narrowing the scope and diversity of thought amongst those voices.

## 9.2 Modern Science in the Curriculum: Genetics vs Genomics

Analysis of the data reveals that genomics came to be introduced into secondary science courses as a result of the desire to better prepare students to interact with potential advancements in genomics medicine in addition to encouraging them to support future genomics research. This was a shared goal of government, the Wellcome Trust, and Nowgen amongst others. While some elements of genomics knowledge were ultimately introduced into the National Curriculum, there were several debates about the nature of its inclusion in secondary science courses. Chief among these debates were questions about whether genomics knowledge should supplant the widely taught single-gene Mendelian Model of inheritance or merely supplement it and the best ways to get teachers to integrate newly emerging knowledge into their practice. Exploring this element of the data did shed some light on the nature of recontextualising new scientific knowledge for secondary students and secondary teachers.

As stated previously, Nowgen's development of NSGP and the 2010-2013 Revision of the National Curriculum in England both played a key role in introducing new elements of genomics knowledge into secondary science courses. Both events were significant in recontextualising genomics knowledge for both teachers in the form of lessons, videos, and laboratory experiences for secondary students or as statements comprising the National Curriculum and the textbooks and exam specifications subsequently based upon it. Data reveals some aspects of how this process occurs.

During the development of NSGP, internal questions arose as to the role of genetics teaching in schools. Nowgen was an organization specifically established around raising public awareness of genetics and genomics advancements but the shift to affecting what was being taught in schools brought about significant inquiries in how the emerging genomics knowledge should impact already established practices in teaching genetics and inheritance. The biggest question was whether the genomics-based approach was meant to supplement the widely taught Classical/Mendelian model of inheritance or replace it entirely. This question about the role of new knowledge in science courses has been studied in the past and the current case provides a window into how these determinations are made (Lewis & Kattmann, 2004; Smith & Wood, 2016; Stern & Kampourakis, 2017).

At the heart of this question is whether the Classical/Mendelian model prepares current students for their futures. At the center of the argument is the question of what science education is actually meant to do. Previously, I outlined how researchers have studied this argument in the past (3.3.1 Classical Genetics in Secondary Schools/3.3.2 Modern Genetics in Secondary Schools). The argument can be narrowed to two specific points of view on the role of genetics teaching. While both sides agree the teaching of genetics plays a key role in preparing students to interact with genetic information in the form of medical treatment, one side places value on providing students with foundational knowledge needed to continue study into post-secondary schooling. The goal is to create the next generation of genetic scientists and researchers (Lewis & Kattmann, 2004). The opposing argument emphasizes teaching those aspects of inheritance that will be useful to secondary students regardless of their desire to pursue further learning in genetics after leaving secondary school. This goal is more in line with developing what is more often called *genetics literacy* in society (Boerwinkel et al., 2017).

This debate is a common discussion in genetics education and the current case gives some insight into how those attempting to develop societal knowledge through school and curriculum approach the question. While both points of view appear in

Nowgen's Manifesto (2012), much of their initial discussions regarding the preliminary development of NSGP leaned towards supplanting the teaching of Classical single-gene genetics with modern genomics. Nowgen considered teaching genomics instead of genetics a faster route to achieving their goal, positing the Classical Model emphasized older views of genetics that lacked a nuanced view of human inheritance that perpetuated a highly deterministic outlook. They also saw the Classical Model as too focused on the application of simple mathematics through the teaching of single gene crosses utilizing Punnett Squares.

Nowgen's discussions on the role of genomics in secondary science courses relative to the more widely taught Classical/Mendelian model were internal to begin with. It is important to note that as an organization, Nowgen was comprised of individuals representing many different organizations and stakeholders. Within the organization individuals had affiliations with the Nuffield Foundation, the Wellcome Trust, and the learned societies. As this was the makeup of the organization, numerous stakeholders with varying viewpoints were brought into consideration.

Researchers have previously explored numerous obstacles with solely focusing on the Classical Model of inheritance. In earlier chapters (3.3.1 Classical Genetics in Secondary Schools), I outlined some of these problems and Nowgen's initial outlook would seem to be consistent with previous findings, focusing on matters such as domain specific vocabulary and terminology, overreliance on mathematical tasks, cellular processes, and making sense of the abstract nature of genetics as a molecular process that leads to physical and chemical outcomes (Knippels, 2002).

While Nowgen initially took this stance, they would eventually adopt a position that focused on supplementing the Classical Model with genomics knowledge as opposed to supplanting it. In the next sections, I will outline what led to this decision and what it reveals about the teaching of contemporary science in secondary courses.

### 9.2.1 Teacher Knowledge in Modern Genomics

Nowgen's shift from supplanting Classical/Mendelian genetics teaching in schools to supplementing it can be linked to their initial approach in developing NSGP. According to the collected data, after securing funding from the Wellcome Trust, Nowgen undertook an effort to conduct research into teachers' attitudes, knowledge, belief, and competency in the teaching of inheritance and genetics. Through the surveying of secondary biology teachers, they found that the majority of teachers surveyed reported knowing a fair amount about single gene disorders such as cystic fibrosis, sickle cell anemia, and Huntington's disease and the mechanism through which they are passed from parent to offspring. Similar numbers of teachers also reported significant confidence in teaching single gene interactions without substantial preparation in addition to highly valuing the significance of this knowledge to their students. This is not surprising, as at the time the National Curriculum, and by some extension GCSE exam specifications and textbooks, focused on these elements. There are numerous links to assessment and what teachers choose to focus on in their classes (Baird et al., 2017; Datnow & Hubbard, 2015; Lau, 2016).

When asked similar questions about multifactorial disorders, disorders characterized by the interactions of multiple genes as opposed to single specific genes, and the role of the genome in the expression of these disorders, Nowgen's research revealed some complications. According to their research, while many secondary biology teachers highly valued the importance of presenting multifactorial, genomics-based disorders such as heart disease, depression, and diabetes to students, they did not report great confidence in teaching the disorders or the mechanisms of genomic diseases. The teaching of genomics would require far greater amounts of recontextualisation for secondary science teachers which meant replacing the currently taught Classical/Mendelian model was likely unrealistic at the time (Nowgen, 2012).

The role of teacher knowledge and belief in developing curriculum and classroom practice has been explored (Cheung & Wong, 2010; Cronin-Jones, 1991). They both play a key role in determining how teachers value content and design lessons to deliver it to students. Van Driel (2008) links this connection of curriculum and practice to the experiences teachers amass through their own schooling, teacher training, and professional development. As this is the case, teacher knowledge and belief in the curriculum is actually fungible and can be altered.

The current case reveals that while teacher knowledge and belief can be a limiting factor, it can be overcome to a certain extent. Nowgen did not abandon their goal of integrating more genomics knowledge into secondary science courses, they merely adapted to the current landscape placing more emphasis on the direct recontextualisation of the knowledge for teachers in the form of NSGP, eventually using the power distributed to them from the government and Wellcome Trust to affect change in the National Curriculum.

### 9.2.2 The National Curriculum and Modern Genomics

The previous section outlined Nowgen's approach to introducing new elements into science courses as an educational organization with the backing of several very powerful allies. While Nowgen, in cooperation with many of these allies, did determine it would be better that genomics supplement the current genetics curriculum as opposed to supplanting it, they would get an opportunity to argue the same question, though this time not internally and for greater stakes.

While NSGP successfully provided teachers with the opportunity to learn how to introduce students to genomics-based lessons in genetics, its minor inclusion in the National Curriculum made it difficult to establish it as a priority for secondary science teachers. As previously established, teachers often make value judgements on class time and lessons based on what is assessed and what is assessed is often based on what appears in the curriculum. In England, exam specifications are typically based on the recontextualisation of the National Curriculum. As this is the case, affecting the National Curriculum represents a way of altering teacher perceptions and Nowgen would have an opportunity in the form of the 2010-2013 Revision.

Nowgen's participation in the 2010-2013 Revision came at the behest of the government running the process. They were recommended to the DfE when asked for guidance on the teaching of genetics and inheritance in the National Curriculum. It is likely their previous relationships with the DoH and the Wellcome Trust firmly established within *Our Future, Our Inheritance* contributed to this opportunity (DoH, 2003). With such powerful allies, it is possible Nowgen entered this process with some perceived power which could be used to move the SNCWP in a specific direction. As alluded to previously, distributed power can be used to the advantage to those less powerful agents.

Nowgen would approach this process in a similar manner to the development of NSGP. Their goal was to see more genomics-based knowledge added to the National Curriculum and their participation in the 2010-2013 Revision represented a great opportunity. The revision process did bring up many of the same questions Nowgen had considered with NSGP. SNCWP considered the role of genetics and inheritance learning in the future of the students and whether the current curriculum best prepared them for it. While internally, Nowgen found teacher knowledge to be a great limiting factor in what can be changed in terms of teaching in science courses and that definitely played a role in discussion within the SNCWP, it can be said a different factors seemed to play a role in bringing changes to the National Curriculum.

In the case for genomics, discussions about introducing new concepts that would require significant amounts of training were discouraged due to reductions in services such as the National Network of Science Learning Centres (Bishop & Denleg, 2006; Holman, 2017). According to the collected participant data, there was a reticence in introducing entirely new concepts due to the current teaching workforce and where it stood in terms of experience and knowledge. As training opportunities were less available than in the past, teachers are often left to their own devices in learning new content. Although changes in curriculum are often accompanied by changes in resources such as textbooks and exam specifications, bringing the entire teaching workforce up to date on any changes can be an expensive process. These limitations create a situation where incremental changes are often favored rather than large scale changes.

The case for genomics was no different in this regard. While some large-scale changes were considered, there was an overwhelming tendency towards small, incremental changes. This preference towards incremental change is exemplified with a discussion amongst the SNWP about genetics language. The curriculum at the time used the term "allele" to describe the different forms of a gene. The term is widely used in science curriculum and the teaching workforce was quite familiar with it. During the revision process there was some discussion about replacing "allele" with the term "variant". Variant is becoming more widely used in genetics research circles as a means of emphasizing the fact that what are considered alleles are actually not different forms of a gene but are actually the same gene but expressed differently due to variation. Adding variant to the curriculum would also give secondary science students an earlier introduction to the term should they continue genetics study in their future while also better aligning the curriculum with current views in research.

While this change was under consideration, it ultimately failed to make the final draft of the curriculum. According to participant data, this lack of change was due to the widespread thought amongst the SNCWP that the change required teachers to alter their thinking, preparation, and lessons centered on the role of alleles in passing genetic information from parent to offspring too much. While the SNCWP saw some benefit in aligning what was taught in science courses with what was currently happening in research labs, the consensus was that the term allele was fit for the purpose of secondary science teaching and learning.

This occurrence is illustrative of the problem with introducing emerging research into science courses. Aivelo and Uitto (2019) found that science teachers typically focus on either subject matter emphasizing fundamental, theoretical concepts or the student-centered issues that could affect them in their near or long-term futures. Combined with teacher tendency to determine the value of knowledge based on personal experiences, this represents a situation in which knowledge that teachers are most comfortable with tends to have the highest value and therefore greater influence in the preparation of lessons. The current case reveals that while informing teachers of newly developed knowledge can be helpful in seeing students introduced to emerging ideas in science, the success of this approach can be increased by connecting the new knowledge with preexisting foundational knowledge and the future prospects of students in regard to science and their everyday lives. This finding brings the current study in alignment with previous work in the matter (Cotton, 2006; Henze et al., 2007; Tidemand & Nielsen, 2017)

## 9.3 The Case of Genomics and the Study of Knowledge Recontextualisation

Previous sections outlined how the observed power structure gives some insight into how less powerful agents are able to influence the processes that select knowledge suitable for teaching in schools. Through the concept of distributed power, the government allowed seemingly less powerful but ideologically aligned organizations the opportunity to contribute to both the determination and transformation of new knowledge paving the way for the introduction of genomics. While one section examined this from a practical policymaking standpoint and the second considered this from the standpoint of genetics teaching specifically, this section will focus more on what the case reveals about the Pedagogic Device as a theoretical basis for studying the formation of new knowledge into pedagogic communication.

### 9.3.1 Knowledge Production and Recontextualisation

As previously outlined, determination on the appropriateness of genomics knowledge for secondary science students came as a result of a desire to increase public awareness. This determination can be tied to two primary goals. The first was preparing the next generation of citizens to interact with genomics-based medicine. The completion of the Human Genome Project was seen as both a scientific and medical breakthrough that held significant potential for the genetic treatment of some conditions. The second was to encourage secondary science students to support the study of genomics as researchers or individuals willing to contribute to genomics studies. From a theoretical standpoint, this determination can be seen as a desire to move genomics knowledge from the esoteric to the mundane.

Of note to the process are the agents involved in determining genomics knowledge as suitable for secondary students were previously outlined. They include multiple governments, initiated by a Labour Government and continued by a Conservative government in coalition with the Liberal Democrats, the DoH, the Northwest Genetics Knowledge Park, and the Wellcome Trust. This is not entirely an educational decision and there is a lack of educational stakeholders involved in the process. This observation becomes even more apparent during the 2010-2013 Revision as the government specifically suggests Nowgen's participation in the SNCWP when it comes to developing the genetics portion of the National Curriculum.

This observation is not wholly unexpected. Literature reveals that both the development and selection of knowledge deemed appropriate for teaching in schools (Production) is often done by non-educators (Singh, 2002). The current case does seem to reveal that as this process is happening, agents associated with selecting the appropriateness of knowledge are also playing a larger role in the recontextualising of that knowledge. In the current case, while educational stakeholders begin to take a bigger role in directing the process, those in power begin to distribute greater power to those with aligning interests. In the language of Bernstein, this blending of processes and agents begins to blur the lines between Knowledge Producers and Knowledge Recontextualisers. As the demarcation of these fields becomes less apparent, those with the power to produce knowledge and select knowledge either directly recontextualise the knowledge or place power in the hands of ideologically aligned agents to recontextualise said knowledge. This process could lead to a scenario in which knowledge is selected based on what benefits the powerful and their allies as opposed to what benefits society.

The idea that the powerful control both the production and distribution of knowledge is consistent with the literature (Singh, 2015, 2017; Wright & Froehlich, 2012). Often, the processes that determine what knowledge is valuable to society, and therefore appropriate to be taught in schools, are heavily skewed towards the powerful. In recent years, this phenomena has become more apparent as the field of politics begins to assert more authority in the field of education, specifically curriculum development (Apple, 2004; Ho, 2007). While political environments are known to affect the development of pedagogic communication in some regards, the recontextualisation of knowledge has primarily been the area of educators. The current case casts doubt on this viewpoint as many of the same agents responsible for the production of new knowledge and the rules regarding its distribution begin to play a greater role in the direct recontextualisation of that knowledge in both a pedagogic capacity (development of teacher lessons and professional development) and an official capacity (development of state curriculum). As there are various processes of recontextualisation throughout the process of education, this observation may have implications for how teachers make determinations for how they focus their teaching efforts.

### 9.3.2 Paths of Recontextualisation

The current case also raises questions on the processes of recontextualisation. Knowledge recontextualisation and the development of pedagogic communication towards  new discourses typically occurs through the training and professional development of teachers (Pedagogic Recontextualising Field) or through the official processes set by governments and local authorities such as curriculum development

(Official Recontextualising Field) (Bernstein, 2004). Pedagogic communication is created from these processes in the form of curriculum documents which inform textbooks, examination specifications, teacher resources, and professional learning. When there is strong separation between the ORF and PRF, knowledge undergoes multiple processes of recontextualisation in addition to multiple interpretations of the subsequent pedagogic communication developed (Singh, 2002). This process in turn leads to processes of secondary recontextualisation at the micro level as teachers make determinations about the value new knowledge has for their students and the time they can devote to teaching and assessing said knowledge. Typically, decisions made on the value of knowledge are often based in concepts such as assessment or the future prospects of students, some of which are developed by the teacher based on the pedagogic communication coming out of several different processes of recontextualisation.

The current case outlines a process in which both fields of recontextualisation are heavily influenced by the same agents leading to far less demarcation between them. This lack of demarcation could lead to a process of recontextualisation where the powerful have greater say in not only what knowledge is valuable but also how knowledge is transformed, creating even greater power structures for those outside of the fields of education. From a social standpoint, erosion of the separation between the ORF and PRF leads to the less powerful having fewer opportunities to affect culture through formal schooling (Singh, 2015).

If the number of bodies that can contribute to the recontextualisation of knowledge is limited to those with interest aligning with the powerful, then the less powerful are likely to remain less powerful. Bernstein (2000) theorizes that pedagogic discourse, discussion surrounding education and the value of knowledge, are never neutral and subject to ideology. This ideology impacts the pedagogic communication formed from pedagogic discourse. Recalling that pedagogic discourse is never neutral and that instructive and regulative discourse exist in tandem to separate skills and knowledge within a subject and to create social order respectively, a further erosion of the separation between the ORF and PRF can ultimately remove decision-making opportunities from teachers in determining the value of what is taught in classrooms. From a theoretical standpoint, this observation could pose problems for using the pedagogic device as a means for studying the development of curriculum as it blurs the lines between the fields of knowledge production and recontextualisation.

## 9.4 Summary

The research questions of this studied were as follows: How did genomics knowledge come to be introduced into the National Curriculum for England and what does this reveal about the processes that transform newly developed research into curriculum and lessons in secondary science courses. In this chapter, I have compared and contrasted the findings of the current study to present and past literature. While the introduction of genomics knowledge into the National Curriculum originated with a desire to increase its public awareness, its pathway towards inclusion included the collaboration between several governmental and non-government organizations in both the public, private sectors, and volunteer sectors. While these organizations reflect a wide range of stakeholder, they actually exhibit a specific vision of the role of genomics knowledge in society and work to affect the teaching of genomics through working with teachers, curriculum developers, exam boards, government agencies.

The study also revealed how this approach to affecting what is taught requires multiple considerations such as teacher knowledge and beliefs, assessment, and the processes that teachers use to determine the value of knowledge to students. Affecting each of the parameters makes introducing elements of contemporary science into teaching difficult as it requires significant resources and capital. Nowgen is ultimately able to achieve this goal through its numerous connections with organizations with greater power.

There are fewer barriers between the forces that drive the selection of knowledge suitable for teaching in schools and those that recontextualise it. Traditionally the recontextualisation of knowledge has been primarily an endeavor of those in the field of education but the current case reveals that a more collaborative approach to curriculum development gives more voice to organizations outside of education. This collaborative process has implications for the way we study curriculum development and how knowledge is transformed from esoteric to mundane.

# Chapter 10: Implications for Further Study

The research questions of this study were as follows:

1. *How did genomics knowledge come to be introduced into the National Curriculum for England?*
2. *What does this reveal about the processes that select and transform newly developed knowledge into curriculum and lessons in secondary science courses?*

This study endeavored to explore the processes that saw genomics introduced into the National Curriculum and what that may reveal about how emerging scientific research is transformed into secondary science lessons. Exploring this process, and those contributing to it, led to findings centered on the social and political environment of the time and the organizations and individuals involved. The findings of the study do have some implications for education researchers.

## 10.1 The Pedagogic Device and the Study of Curriculum Development

The pedagogic device has often been used as a means of studying the power structures involved in determining what knowledge is appropriate for recontextualisation and teaching. The influx of new participants in the process, specifically those engaged in both the production and recontextualisation of new knowledge, makes it harder to determine where one process ends, and another begins. From a theoretical standpoint, this ambiguity makes application of the pedagogic device in national curriculum processes more difficult than in the past as this blending of government and non-government influence on curriculum development continues. This arrangement is likely to continue as more participants seek the opportunity to contribute to curriculum development as a means of affecting societal knowledge and understanding of rapidly changing scientific progress. This arrangement also has implications for the processes researchers use to determine the rules that govern the pedagogic device in addition to the fields.

This observation by no means makes the pedagogic device obsolete as a theoretical lens for studying how knowledge is transformed from domain-specific to the understanding of the layperson, but more research should be devoted to better fleshing out how this blending of roles may affect the curriculum development process at the national level and how this arrangement subsequently affects decision-making by teachers tasked with delivering the newly developed curriculum.

In Chapter 5, I introduced Figure 5.1 to visually represent how the pedagogic device is meant to convey how new knowledge is transformed into pedagogic communication. This figure can be seen below:

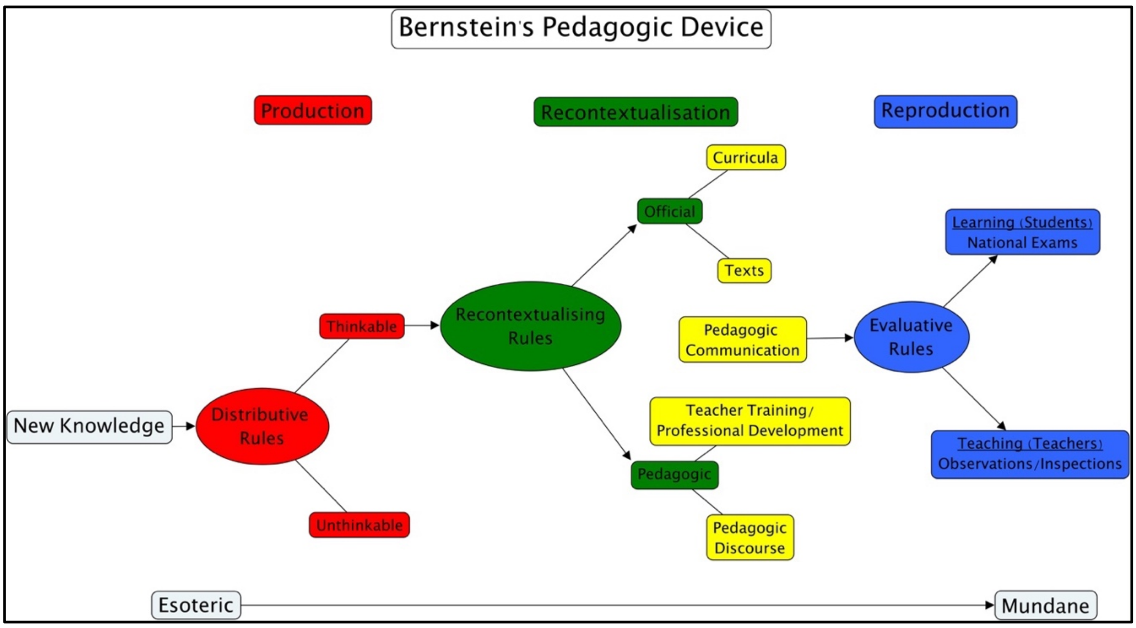


**Figure 5.1 Bernstein's Pedagogic Device** This outline of the pedagogic device establishes the hierarchal movement of knowledge through the fields of Production, Recontextualisation, and Reproduction.

While this figure highlights the hierarchical nature of the pedagogic device and the transfer of knowledge from production to recontextualisation and recontextualisation to reproduction, the current case casts some doubt on this viewpoint. The introduction of genomics into the National Curriculum outlines a process where there is greater overlap between the fields of production and recontextualisation and new models may need consideration. Figure 10.1 outlines some adjustments to the model based on the current case:

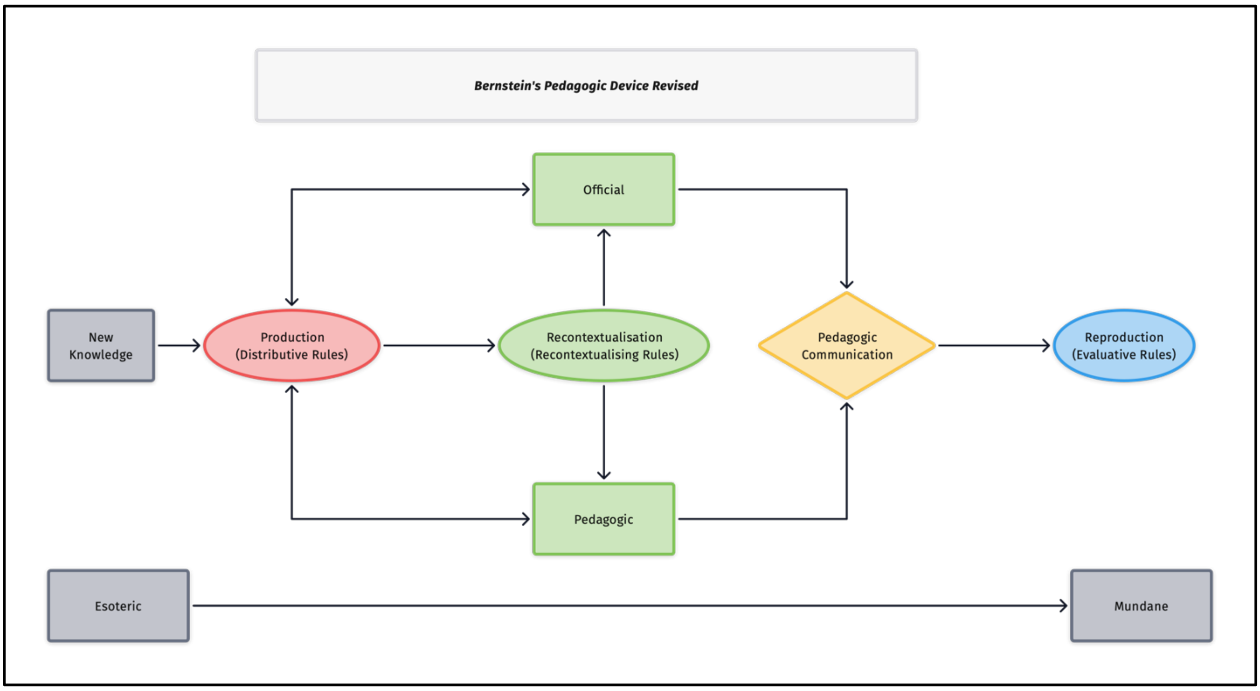


**Figure 10.1 Revised Pedagogic Device**

While the previous model emphasizes the hierarchal nature of the pedagogic device, this revised model seeks to highlight the overlapping nature between the fields of production and recontextualisation as highlighted by this study. With the development of distributive power structures that bring new organizations into the fold, knowledge no longer flows from the field of production to the field of recontextualisation in one direction. It would seem that while the field of production can be seen less as determining what audiences will receive what knowledge (thinkable from the unthinkable) and more focused on the pathways knowledge will take towards recontextualisation (Official or Pedagogic). Even as this determination is made, agents on the field of recontextualisation may still interact with agents from the field of production in transforming the knowledge into new forms of pedagogic discourse and communication. This arrangement creates multiple pathways of recontextualisation as both Official and Pedagogic recontextualisers consistently work with and through the agents that determine new audiences for developing knowledge.

### 10.2 The Study of Genetics Teaching and Learning

The study of genetics and inheritance at the secondary school level has been primarily focused on the Classical Mendelian model since its inception despite the growing influence of genomics on our everyday lives (Gericke & Smith, 2014; Strachan et al., 2014). While debate about the role of genomics in the future of students requires greater scrutiny, the current study did outline some aspects that influence how teachers emphasize what aspects of genetics they will teach. A combination of curriculum, assessment, and personal knowledge and beliefs often play a big role in how teachers determine what is valuable for their students (Cheung & Wong, 2010; Henze et al., 2007). While the current study affirms that introducing new genomics knowledge into the genetics curriculum likely requires some adjustment to teacher knowledge and belief about the value of genomics knowledge to students, it also highlighted a lack of research into the processes that teachers specifically use to transform pedagogic communication into lessons for their students.

Current literature often highlights the importance of varying approaches to teaching genetics and inheritance (Banet & Ayuso, 2000; Lewis et al., 2000; Smith & Wood, 2016). This research is often accompanied by discussion on the pros and cons of teaching genetics from a historical model as opposed to one based in emerging findings and the ethical implications (Dawson & Venville, 2010; Stern & Kampourakis, 2017). The current study highlights the processes of recontextualising genomics knowledge into pedagogic communication at the national level and affirms what influences teachers in recontextualising that communication for their students but falls short in outlining how teachers carry out decision-making in this regard. As more aspects of genetics teaching and learning begin to incorporate emerging research that could affect the lives of modern students, it is paramount that the processes teachers use to directly recontextualise this information are more firmly studied and understood.

### 10.3 The Increasing Role of Non-Education Influences on Science Education

The current case also highlights the increasing number of individuals and organizations outside of what can be considered the traditional field of science education that are affecting the profession. Studies are showing a growing tendency towards governmental policymaking through collaborative efforts between public and private sector organizations in the field of education (Ball, 2008; Ball & Exley, 2010; Goodwin, 2009). While this tendency has been the case in a number of areas outside of education, it has specific implications for science teaching and learning.

As smaller organizations like Nowgen partner with government and larger organizations such as the Wellcome Trust in delivering science content directly to teachers, there is a chance that that the recontextualisation of knowledge could move further and further away from the purview of educators. It is unlikely educators will ever be completely shut out of recontextualisation processes but diminishing the role of educators in national curriculum processes in favor of other organizations could result in changes in the ways that teachers recontextualise pedagogic communication directly for their students in similar manners to the “Parental Rights” Movement in United

States curriculum circles (Tan et al., 2020; Thomas et al., 2020). This movement has seen science teachers navigating between trying to teach modern concepts in science that are personally relevant to current students and “traditional” science concepts preferred by current governing bodies.

Along with other studies, the current case highlights how many organizations outside the traditional field of education get the opportunity to contribute towards curriculum development (DfE, 2010, 2013b; Gallagher et al., 2012; Millar, 2011). While organizations such as the learned societies and the Nuffield Foundation have been contributing to the development of science curriculum for some time, there is concern about the growing reach of non-educational organizations brought into the fold by governments looking to make changes to what is being taught (Knox, 2022; Miglani & Burch, 2021). As these networks of curriculum developers grow, there will be a burgeoning need for more research into how non-education organizations are influencing education through the recontextualisation of knowledge at the national and local levels.

## 10.4 Conclusion

The research questions of this study focused on determining how genomics knowledge came to be introduced into the National Curriculum for England and examining what that may reveal about the processes that transform newly developed knowledge into curriculum and lessons in secondary science courses. The current study revealed some need to reconsider how the pedagogic device is utilized as a means for studying the transformation of knowledge in an age of collaborative policymaking. It also outlined how science education, specifically genetics teaching, has been changing.

As both of these processes continue there is a growing need for more research into how these changes will affect science teaching and learning moving forward.

As with any study, there are some important limitations to make note of. The current study was unable to obtains participants that had specific experience working within the Civil Service during the 2010-2013 Revision to the National Curriculum. Attempts were made to reach out to individuals with this particular experience but were ultimately unsuccessful. While this is the case, several of the participants of the case did have experience working with the Civil Service and when appropriate did speak to their experiences.

As previously outlined, snowball sampling was used as a means of recruiting a participant sample with expertise in the area of science education but diversity in professional experience. The participants provided experiential data that focused on questions and descriptions about the processes that ultimately saw genomics knowledge added to the National Curriculum for England. The sample held significant expertise within the subject matter of the case and steps of triangulation were taken to try and limit bias. As such, saturation of important themes was reached giving the study sufficient enough data to support its findings and conclusions.

While the sample does not have direct representation of members of government, there is sufficient representation of individuals with experience with interacting with government at this level to provide some generalizability to the case. As the processes that saw genomics introduced into the National Curriculum encompassed numerous organizations and bodies, it can be said that the findings and conclusions of this study may be extended to other cases of recontextualising knowledge, specifically through the curriculum. As more organizations seek opportunities to bring newly developed knowledge directly to the public through media, it is very likely there will be continued emphasis on what constitutes the curriculum and who gets to contribute to its creation. If these processes continue towards a more collaborative structure, then the findings and conclusions of this study may provide a blueprint for continuing to study newly evolving processes in the future.

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Appendix A: Information Sheet and Consent Form

# ***UCL Institute of Education***

Information and Consent Form

Research Project Title: The Case for Genomics: Introducing Elements of Emerging Science Research into Curriculum

**A. Purpose of this research:** The purpose of this study is to investigate the processes that potentially transform science research into curriculum and classroom practice. The focus of the study is the current debate on genetics education in the United Kingdom and efforts to influence curriculum changes at that would potentially affect individuals across varying levels of science education.

**B. Procedure/Treatments:** You will participate in a series of in-depth, narrative interviews conducted by the principal investigator held at your convenience. All interviews will be recorded and transcribed.

**C. Expected Length of Participation:** The time of the interviews will vary according to your responses and follow up interviews may be required.

**D. Potential Benefits:** Participants will be given the opportunity to contribute their views and experiences to the ongoing debate on genetics education in the U.K.

**E. Potential Risks or Discomforts:** Participants will be engaging in audio-recorded interviews.

**F. Contact Information for Researchers:** Participants may contact Teremun Rider or Ralph Levinson (Ralph.Levinson@ioe.ac.uk) with any inquiries pertaining to the study.

**H. Contact information for UCL IOE Ethics:** For inquiries about rights as a research participant contact the UCL Research Ethics Committee at (0203) 108 8216 Ext: 58216 or ethics@ucl.ac.uk.

**I. Explanation of confidentiality and privacy:** All participants' data will be kept confidential. All participants will be given aliases and the actual names and aliases kept in separate password protected files, as will all other data collected. This data will be kept on a laptop within password-protected files that only I will have access to.

**J. Assurance of voluntary participation:** Participation is voluntary. In the event that you are uncomfortable with these interactions at any time you may remove yourself from the study. Your data will be removed from the study also.

**AFFIRMATION BY RESEARCH SUBJECT**

I hereby voluntarily agree to participate in the above listed research project and further understand the above listed explanations and descriptions of the research project. I also understand that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty. I acknowledge that I am at least 18 years old. I have read and fully understand this Informed Consent Form. I sign it freely and voluntarily. I acknowledge that a copy of this Informed Consent Form has been given to me to keep.

Research Subject's Name: ______________________________________________

Signature:______________________________________________________

Date:________________________________________________________

Appendix B: Interview Protocol

| | |
|---|---|
| ***Subject/Participant:*** | ***Date:*** |
| ***Recommended by:*** | ***Known Experience with the Case:*** |
| ***Start Time:*** | ***End Time*** |

***Protocol:***

- **Presentation of Consent Forms, recognition of recording permission, and assurances of confidentiality**
- **Introduction**
- **Initial Question (I am studying how genomics came to be introduced into the National Curriculum for England. What can you tell me about that?)**
- **Follow-up questions**
- **Clarifications**
- **Recommendations for further Participants**

***Follow-up Questions Asked or Further Inquiries:***

***Literature/Documentation Recommended:***

***Participants Recommended:***

Appendix C: Transcription of Ginny W Interview

Interview with AH 5/12/16

I:
At the current moment I'm looking and interested in the movement towards teaching genomics in secondary schools. What can you tell me about that?

R:
*My experience that is relevant to this is in the discussion around in the most recent changes in the national curriculum but also in curriculum development which wasn't so tied to the existing national curriculum before that so I'll talk about those separately*

*So prior to this last curriculum I was involved in the development of an A-Level course called Salters-Nuffield Advanced Biology, or SNAB, and also a course which the Qualifications and Curriculum Authority (QCA) that existed in those days, this is back in 2004-2006*

*They piloted a new GCSE course called 21 Century Science, so I was involved in the development of that*

*So the first one, the A-Level course which I became involved in in the year 2000 we looked at what an A-Level should contain and we basically had to cover what was in the Key Stage 5 curriculum but we had a lot of scope outside of that*

*It's a context lead course so we can introduce material which is about the story of why you're learning the facts that are in the curriculum and we took the view that you should introduce cutting edge science so we did introduce genomics quite lightly*

*We introduced it as a concept, we introduced the idea of large scale studies which other A-Level biology courses hadn't necessarily addressed at that point*

*So we looked at it through the context of health and multifactorial diseases and then we looked at genomics and genetics in terms of biodiversity, another topic, so we looked at how you can map pedigrees and use that for ex? to conservation and we also had a whole topic called the voice of the genome which is looking at development*

*And so we didn't take the traditional approach genetics, teaching Mendelian genetics and then sort of moving on to an application*

*We actually took these contexts and looking at the relevance of advances in genetics research to those topics*

*And then in the 21st Century Science development which was for younger pupils we took the same approach really*

*We did look at how you map, how you run analyses of genomes and looked at large scale studies*

*I should also mention there was a course prior to that earlier than either of those two which was called Science in Society*

*Have you heard of this course? That was an A-Level course*

I:
I have not

R:
*No, it had prerunner called Science in Society, which was only an AS course*

I:
AS?

R:
*AS which is just the first half of A-Level so you could only do it as a sort of add on to A-Levels and it was intended for either students studying science who wanted to broaden their science education to more societal issues or the non scientist who wanted to keep some science going but not necessarily studying science at a more advanced level but looking at it broadly*

I:
OK

R:
*And those, that course, both of them, particularly the most recent one where we had A-Level, again it looked at the influence of multifactorial influences on health and disease, lifestyle and looked at how you can measure the genome, how you can map it, the sort of studies that help to determine what advice to give people and also for drug development, there's a whole section on drug development*

*And we talked about personalized medicine, that sort of thing, that was sort of the topic*

*So have you read the study called "Beyond 2000"?*

I:
I have not

R:
*So in 1998 there was a big study or a paper by Robin Miller and Jonathan Osbourne, Jonathan has done a lot of work on the curriculum in the states, and they weren't the first people to say this but they basically put together an argument that the current science education, at the time, was suitable for future scientists but it wasn't suitable for people who aren't going on to be future scientists and as most pupils, the vast majority of pupils are not going to be scientists, is this curriculum fit for purpose?*

*So they discussed in the paper, which is easily accessible online, they discussed the sort of things that might be introduced into courses that were more for to broaden the range of interest in science*

*No to, they didn't at that point argue that you need separate courses necessarily but that you might have different ways of approaching science more broadly*

*And so that was the basis for these two courses, Science in Society and Public Understanding of Science in Society and the whole of the trial by the QCA with the GCSE course 21st Century Science was based on their paper so it was looking at how you might think about what science is for future scientists and non scientists*

*And more recently I was involved when I was working at the Nuffield Foundation*

*I was involved in the Royal Society of Biology and, in their working party looking at the looking at the content of the new curriculum*

*Now the trouble is, when you're trying to develop a new curriculum, particularly in biology I think, there are a lot of professional bodies associated with every area of biology mycology, parasitology, ect. that think their content should be included in the school curriculum and it's very difficult to get anybody who's capable of leading on the decisions that need to be made around what should and what should not be in the curriculum but I think there was a pretty big consensus that we needed to update the content around genetics*

*Even so there was a big debate about whether what you should need to know by the age of 16, which is the National Curriculum, should you start with Mendelian genetics and get people to understand the mechanism of inheritance and then at advanced level go on to talk about the more recent advances and the way we look at genomics, population studies or should you do it the other way around and we had arguments on both sides because you could start teaching genetics from looking at a population and the proportion of people with different attributes and so on but it's almost impossible to get fundamental changes*

*I think people are strongly tied to what they learned at school and therefore what they think everybody should know and I don't think there's enough long term ongoing debate between educationalists and scientists about what are the building blocks of the knowledge you need to work in that area*

*So we did get some changes and we were very strongly in touch with Matt Hickman who I put you in touch with at the Wellcome Trust who at the time was working on a big educational program for genomics in schools*

*He was very articulate and managed to sort of convince people*

*It was kind of depressing that it hinges on individuals being able to argue the case rather than ther[e being a proper process of what should be in the curriculum and how that decision is made*

*In the end there were some small changes, some allusions to genomics right down into the GCSE but you have to think "well what do teachers understand by this" and there wasn't any sort of program of professional development associated with this change so I don't know what's actually happening in schools and I haven't been as involved in directly in* *schools since that time but certainly there is a pretty good consensus that we needed to update the genetics contents and genetics topics*

*But I still think it's taught pretty traditionally and genomics would be an extension of what we used to teach before which is one way of doing it*

I:
In some of my research I'm actually looking at what's in the curriculum right now and for the most part it's still classical genetics but there has been a change in Key stage 4 which is pretty small but it's there

The word genomics first appears in the curriculum and I think those changes were made in 2014

R:
*That's right. The word's there. That's the most recent change*

I:
Please continue

R:
*Well I think that's just about it*

*We did commission, when I was working in Nuffield, we did commission somebody to write some teaching materials which you probably would find actually still*

*I found some for this course the other day*

*If you search on Science for Public Understanding or Science in Society which is the most recent version and you look at resources you'll get to a page where you can look by topic and you will see some materials that were produced on large scale studies and I can't remember the exact topic but I think it was how they inform, yes they had a medical context*

*I can't remember if it was drug development or looking at contributing factors to multifactorial diseases but there are resources*

*But that course didn't actually last very long, because with the most recent changes in the curriculum it died a death and wasn't included in the new curriculum, we don't know how teachers got on with that particularly*

*I think that's more or less all I have to relate*

*I don't know if there's more you'd like to ask…*

I:
Can I get you to clarify a bit of the timeline there? There was the A-level course in 2004?

R:

*Yes so the A-level course was piloted from 2004 and actually went public in 2006 but I'm not absolutely certain but that was called SNAB*

I:
And this is all after 2003 and the completion of the Human Genome Project and the genetics white paper?

R:
*Yes that's right*

*So that course, SNAB, one of the things you had to do for the AS course, the lower 6th, or first first year of the study, was a visit or a report on an issue so people around sort of the area of Cambridge and that side of England did actually visit the Sanger Institute in Cambridge and they run outreach from there*

*In fact that's another thing, I don't know how much I have about it to say at the moment as I'm actually on the advisory committee for educational outreach for the Sanger Center and I know they are doing a lot of outreach but it tends to be local rather than national but they would be interested in talking to you if you wanted to give them a call*

*They've just appointed a new education outreach director so that'd be worth going to visit and it's rather good to see*

*So some of the students will have visited and done their report on the visit and what the scientists say and while they're there they would have asked some questions but unless they did that special little study I think that the influence of genomics would be fairly small even in these courses I'm talking about but at least there would have been an awareness that genetics isn't just about inherited diseases and eye color and gender….*

I:
Or the color or peas….

R:
*Yes, there's more to it. (laughs)*

I:
Yes, Question, Where do you think the motivation came to changing the curriculum? I know you spoke on it a bit but can I get you to elaborate

R:
*Yes ok, that's a complex question because I think the driver is university entrance still*

*I think there's always lip service given to what employers say*

*So whenever there's a chance in the curriculum there's a lot of employers involved in having a chat about what is needed but in the end but our education system is driven by university entrance requirements and that is A-Levels and A-levels are designed according to what is needed by the universities for their undergraduate courses*

*So if you talk to people at universities you get some conflicting messages*

*Sometime they say, I've actually spoken to university lecturers who say "Just don't teach them too much about biochemistry for example because teachers get it wrong and they (students) have misconceptions when they come to university and what's really important is that they know how to learn and have study skills and that they have some practical skills and know how to carry out an investigation"*

*And others I've spoken to say what's really important is that they have the building blocks of knowledge in place, that they know what a cell is and you shouldn't be talking to them about fancy stuff like genomics because they haven't got the fundamentals of what's in a cell and how the most simple biochemical pathways work*

I:
Sort of the "you can't teach calculus if they can't count to 10" argument?

R:
*Yes that's right*

*So they're frustrated by the core knowledge which never adds up when you talk to people because if you look at what they're saying is lacking, it's actually present in the curriculum*

*So they say that students don't know about simple cell structures but why not? They've done it GCSE and they've done it at A-level so why don't they know it and I don't understand why they don't and it's usually things that are in the curriculum that they're complaining are not in the curriculum*

*So there's something about the way that students translate what they know when they get to a new course and studying it impacts different cont? for situated learning and they can't transpose it from one situation to another*

*But I think the main driver is university and employers*

*We've had dabbles in this country with vocational courses and an advanced diploma and that came to nothing and that's quite political*

*It tends to be the right wing conservative government who didn't want the diploma and it sort of all crashed when they came back into power*

I:
When they came into power recently?

R:
*No originally after Tony Blair's and Gordon Brown's government so when Cameron came in so we've had them for a while now (laughs)*

*But there was a diploma development in the earlier part of this century sort of around, it must have been around 2007ish I think although I'm not sure about that but there were* *plans and a lot of money spent on the development of a science diploma and industry were very well represented to that but it came to nothing*

*But the driver, yes I don't think you could argue it's anything other than university because the GCSE has to feed A-Levels and A-Levels have to feed university*

*I mean that may be a bit cynical (laughs)*

*If you look at the aims of the national curriculum they're broader than that but I think employment roots are secondary*

*The most recent change in the curriculum, I don't know if you've looked at the one prior to 2014*

*The 2006 curriculum at key stage 4, there was a lot more content that was not factual so there was a lot more about applications and implications of science and the processes of science*

*What we've returned to is a much more traditional curriculum with a lot more factual knowledge*

I:
I think we see the mirror in my country where we've kind of made the change but there's some pushback right now

R:
*Yes I'm interested because Jonathan Osbourne who wrote this Beyond 2000 report actually went out to work on your new science curriculum so I'd have expected him to be putting quite a bit about the application and implications of the broader science and you're saying he's done that but there's a pushback?*

I:
(pauses) We can go on to that a bit later

R:
*There's a tension there you could say*

*I've heard Michael Gove, the previous secretary of state for education, he says that if you're talking about access it's not fair to give some people knowledge and not others*

*In other words you should have a very fact based curriculum because that gives people the root out of their socioeconomic position in society*

*(pauses)*

*And I don't know*

*On the other hand, if you're turning off a whole load of people to science because it's very fact based and it doesn't connect with their lives then that's also an issue*

*I don't see it as a polarized dichotomy myself*

*I see it as something that you can, whatever the curriculum, you can teach it in different ways and you can use context and applications*

*But it's whether genomics should be something that's assessed I mean that's what it comes down to, whether it's assessed or whether it's a context*

I:
Ok

R:
*So with the most recent curriculum they tried to…*

*There's somebody called Tim Oates, you might want to look at his paper called, I think it's called "Could Do Better"*

*He talks about how context should not be written in the curriculum and that the curriculum should be pure and that context should be something is something that you add as a teacher*

*He heavily influenced the most recent version of the curriculum*

*You could argue that they need to know and be assessed on mendelian genetics but genomics is a way of motivating students to learn about genetics because you can see all the wider applications of genetics as a science*

*So there are two ways of arguing it*

*You could say we need to introduce more cutting edge science into the curriculum and that needs to be assessed but if you put something in you have to take something out otherwise you overload the curriculum*

I:
You only have this much time

R:
*That's an issue I have been involved in because when you develop a context lead course, you have to take out some of the curriculum content that people think of as essential to an A-level course or a GCSE course*

*But you've got to make time for this sort of discussions and problem solving that is involved if you're trying to develop skills and understanding of how science is applied*

*I:*
Yes I totally understand, (those are) some of the things I considered when I was teaching

I would like to ask you a little bit about policymaking

I heard you say it's kind of difficult to get in the room with those individuals who have the power to make those kinds of decisions

What kind of steps do you think you guys did to get in the room with those individuals and do you think doing those steps differently might have lead to different impacts?

R:
*So with the last curriculum changes…*

*So ok the previous curriculum changes after 2000, for sciences just only, were based on a proposal to the QCA by the authors of the Beyond 2000 report and it was a very adventurous trial of a very different sort of course*

*I would say there is a sort of almost (looking for words) drive from the academic education community there saying we thought really hard about what science education is for and who it's for*

*And that was taken up by because of the people who were at the QCA at the time, which was a non-governmental organization (NGO)*

I:
Non-governmental?

R:
*Yes so it wasn't a governmental department but they were/had a direct line of access to the civil servants*

*It's called an NGO*

I:
There we go

R:
*So the conservatives closed QCA when they came in, it doesn't exist now and so the most recent curriculum change, it's difficult to say who drove it*

*They were happy for the three professional bodies, The Royal Society of Chemistry, the Institute of Physics, and the then Society of Biology which is now the Royal Society of Biology, to take a lead*

*There was a policy group called Science Communities Representing Education (SCORE) which consisted of those professional bodies plus the Association for Science Education and the Science Counsel and they used to meet and it became a group of representatives from those organizations that did have a direct influence on policy*

*So civil servants would to talk to SCORE if they wanted to have a view on science education*

I:
OK

R:
*Whether that was a good idea or not I don't know because it took the science education academics out of the loop and the quality of the discussion was reliant on the individuals who represented the IoP and the SoB and to some extent they weren't necessarily educationalists*

*So it was sometimes good it was sometimes very poor indeed*

*So when the new curriculum came up it seemed the obvious thing to say (was) that the 3 bodies will develop the physics, chemistry, and biology curricula and try and consult on things that they share*

*It was very clear that the physical scientists and the biologists disagreed immediately about the content in terms of the additional content about applications and implications*

*The physicists saw that as diluting the curriculum and the biologists were keen to keep the ethics, in fact the word ethics is still there once I think in the key stage 4 curriculum, and the chemistry lot was somewhere in between*

*The individuals who (were) appointed by the professional bodies to do this curriculum development were people who had time to do so they weren't employed by those professional bodies and again they weren't the right people in my view to do that, it should have been a more consultative process*

*So the physicist was Paul Black who was very imminent scientist*

I:
AFL Paul Black?

R:
*Yes Paul Black from Assessment for Learning*

*He's a great guy but he just did it all on his own, he wrote the physics curriculum and that's not the way to do it*

*The chemist was also not thought of as the right person*

*The biology person was the author of text books so she had been a teacher but she isn't an education academic and she's written good text books but they're very traditional and she took this on and has the time to do it but again you could argue she wasn't the right person, she didn't' have a deep understanding of curriculum development and the people who did probably weren't available to do that work*

*We used to meet at the Royal Society of Biology and there was a representative from partner organizations who had an education people*

*So for example the biochemical society has an education coordinator so they would come*

*The physiology society, the society of general microbiology, etc…*

*These people sent their representatives their representatives to be part of this so called "dialogue" about how the curriculum should be*

*Again, they were people who were working in outreach for their subject area*

*They weren't specialists in curriculum developments and they didn't have that experience and they also didn't know about educational research and what research tells us about the order you should teach things in, the way you can build up a curriculum, etc*

*So it was quite a…..*

*It wasn't a terribly coherent discussion I would say*

*But people were asked to express their views and these leads went away and wrote what they'd thought we'd said and we argued a bit more about it*

*But then it went to the dept. of education and it came back as it is now so a lot of what we talked about wasn't really acknowledged*

*Yes, so it had to be much more factual than we were hoping*

*You couldn't have for example, learning outcomes that were around ethical arguments that applied to a lot of different issues in biology*

*There is a lot in the previous curriculum around the development of science*

*It's almost the philosophy of science really and the nature of science but that's really been cut back so you're really down to the learning outcomes that are around curriculum topics*

*So that's what the process is, it goes to civil servants who then act on what they're told by the mp's in terms of what the policy is*

*So the policy comes ahead of being informed by either research or experts in the field talking*

*And they say it's evidence based but they do all this international comparative work and they look at the countries that are doing well*

*Tim Oates actually does, when you read his paper he does understand how you should be looking at international comparisons, but I think the government (MP's) just get the headlines "That's Country's Doing Well" so we should be like them*

I:
We should follow what we they do

R:
*Yes, which is quite frustrating*

I:
I can imagine, I really can

R:
*So I don't know if I mentioned to Ralph have you spoken to Professor Michael Reiss yet?*

I:
I haven't yet

R:
*You are going to talk to him aren't you because he's been very heavily involved in curriculum development for years*

I:
I'd like to speak with him

R:
*He's a good person to talk to*

*I'm trying to think of anything in policy….*

*(Pauses and thinks)*

*It may peculiar as I don't know if it's the same in America but the civil servants change jobs farily regularly so they are sent to the dept for education and then, after maybe 3 or 4 years, they may be sent to a completely different dept*

*So again they're not specialists in education*

*They tend to then commission the odd expert, they choose people who have the kind of political agreement with their policies as their experts so to reinforce*

*They will only ask people who reinforce what they're thinking anyway but it's quite difficult to push against that*

*I also think, and it'd be interesting to see what Ralph and Michael think, there's an increasing cynicism about educational research and its role*

I:
That's kind of what I started looking at when I came here

The role of ed research in policy making and classroom practice

I'd still like to write a little bit about it

R:

*Yes I think it's really relevant*

*It's difficult because you've hound in a one subject here which is genomics but in a way it illustrates some broader things about whether context or content should lead*

*There's been a lot of work on context lead courses here with the Salters courses, Judith Bennett is the author who's written a lot about those*

*And there's been a lot of talk about getting cutting edge science into the curriculum to make it seem more relevant and I think the feeling on the cutting edge science is that you shouldn't try and be too cutting edge because things change so quickly*

*So when Dolly the sheep was cloned*

I:
I remember

R:
*It was in all the textbooks*

*But of course it became very old hat after 3 years, I can't remember how long she lived, not that long, but she died and then it was really the most recent bit of news but you've got it stuck in your textbooks so people are now saying perhaps we should stick with the fundamentals of science and then you can still use things from the newspaper or websites but don't start having Dolly the Sheep as something you examine because it will go out of date so quickly*

I:
The "how to" of science? I can understand those things.
R:
*Yes that's right*

I:
Well I think you've given me to consider and discuss

Is there anything else you'd like to add?

R:
*Good (laughs)*

*No but if I think of anything now that I know what you're interested in*

*The only thing I doubt is my background is educational design and I think it's not something that's considered an academic area of study in this country whereas it is in the states and it is Europe*

*So I think we suffer from that and we're not very good at developing curricula and if you think of the work that's been done by the AAS in the states, they poured millions, I don't know how much all that cost but it's an awful lot of money isn't? Probably thousands of* *thousands, maybe millions actually and I don't think we can really replicate that work and it seems very odd to me that we don't sometimes look at that*

*But that whole area of curriculum development, there's no proper process in the country I would say*

I:
To me that's the interesting thing about it because sometimes I feel like we don't necessarily look at curriculum development as policy creation when it is a policy in education, possibly one of the most important ones

I've found in my reading when you talk about changes to the curriculum and the process and people thinks maybe it's a policy but what is the process

R:
*Or whether the process should not be policy or that the policy should be to leave curriculum developers to do the job*

*That could be a policy*

*The mp's, for example, and current government they learned long division when they were 8 and they think every 8 year old should learn long division*

*And they have limited experience but they have a view on education that isn't terribly well informed and the policies sometimes doesn't really chime with what educational research tells you*

I:
Yes it's one of the things I'm looking at

Does policy drive practice or does practice drive policy or is it just a big circular theme that no one wants to define

R:
*Yes it's a really interesting area and a needed area of study*

I:
Yes

Well thank you for your time

R:
*Thank you and do get back to me if you want to talk more but otherwise it was really interesting talking to you*

I:
Thank you

Appendix D: Inductive Coding Scheme Ginny W

| Statement | Construct | Codes | Notes |
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| *My experience that is relevant to this is in the discussion around in the most recent changes in the national curriculum but also in curriculum development which wasn't so tied to the existing national curriculum before that so I'll talk about those separately* | **Science curriculum development** | *Personal experience | |
| *So prior to this last curriculum I was involved in the development of an A-Level course called Salters-Nuffield Advanced Biology, or SNAB, and also a course which the Qualifications and Curriculum Authority (QCA) that existed in those days, this is back in 2004-2006* | **Science curriculum development** | *Personal experience | Worked with the Salters-Nuffield |
| *They piloted a new GCSE course called 21 Century Science, so I was involved in the development of that* | **Science curriculum development** | *Personal experience | |
| *So the first one, the A-Level course which I became involved in in the year 2000 we looked at what an A-Level should contain and we basically had to cover what was in the Key Stage 5 curriculum but we had a lot of scope outside of that* | **Science curriculum content** | *21st Century Science<br><br>*Scope of Key Stage 5 | |
| *It's a context lead course so we can introduce material which is about the story of why you're learning the facts that are in the curriculum and we took the view that you should introduce cutting edge science so we did introduce genomics quite lightly* | **Salters-Nuffield Advanced Biology (SNAB)** | *Course design<br><br>*Modern science in the curriculum | Context lead – teaching of science based on the context of the learner |
| *We introduced it as a concept, we introduced the idea of large scale studies which other A-Level biology courses hadn't necessarily addressed at that point* | **SNAB** | *Genomics teaching in SNAB | |
| *So we looked at it through the context of health and multifactorial diseases and then we looked at genomics and genetics in terms of biodiversity, another topic, so we looked at how you can map pedigrees and use that for example to conservation* | **SNAB** | *Genomics teaching in SNAB | |
| *And we also had a whole topic called the voice of the genome which is looking at development* | **SNAB** | *Genomics teaching in Snab | |
| *And so we didn't take the traditional approach genetics, teaching Mendelian genetics and then sort of moving on to an application* | **SNAB** | *Genomics-based approach vs. Classical Mendelian genetics | |
| *We actually took these contexts and looking at the relevance of advances in genetics research to those topics* | **SNAB** | *Modern science in the curriculum | |

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| *And then in the 21st Century Science development which was for younger pupils we took the same approach really, we did look at how you map, how you run analyses of genomes and looked at large scale studies* | **21st Century science** | *Genomics teaching in 21st Century | |
| *I should also mention there was a course prior to that earlier than either of those two which was called Science in Society. That was an A-Level course* | **Science in Society (SiS)** | *Genomics teaching in SiS | This genomics-based approach was used across several different courses |
| *AS which is just the first half of A-Level so you could only do it as a sort of add on to A-Levels and it was intended for either students studying science who wanted to broaden their science education to more societal issues or the non-scientist who wanted to keep some science going but not necessarily studying science at a more advanced level but looking at it broadly* | **Science in Society target audience** | *Targeting of specific audiences<br><br>*Science education for future scientists vs everyday people | Sounds like the differentiation between Thinkable and Unthinkable |
| *And those, that course, both of them, particularly the most recent one where we had A-Level, again it looked at the influence of multifactorial influences on health and disease, lifestyle and looked at how you can measure the genome, how you can map it, the sort of studies that help to determine what advice to give people and also for drug development, there's a whole section on drug development* | **SNAB and 21st Century science** | *Genomics teaching in upper secondary courses<br><br>*Potential medical application | Precedent for introducing genomics into secondary classes was set prior to the 2010-2013 Revision |
| *And we talked about personalized medicine, that sort of thing, that was sort of the topic* | **SNAB and 21st Century science** | *Potential medical application | |
| *So have you read the study called "Beyond 2000"?*<br><br>*So in 1998 there was a big study or a paper by Robin Miller and Jonathan Osbourne,* | **Beyond 2000** | *Science education literature | |
| *Jonathan has done a lot of work on the curriculum in the states, and they weren't the first people to say this but they basically put together an argument that the current science education, at the time, was suitable for future scientists but it wasn't suitable for people who aren't going on to be future scientists and as most pupils, the vast majority of pupils are not going to be scientists, is this curriculum fit for purpose?* | **Science curriculum philosophy** | *Science education for future scientists vs everyday people<br><br>*Is the current science curriculum achieving its goals? | |
| *So they discussed in the paper, which is easily accessible online, they discussed the sort of things that might be introduced into courses that were more for to* | **Science curriculum philosophy** | *Science education for future scientists vs everyday people | |

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| *broaden the range of interest in science* | | | |
| *Now, they didn't at that point argue that you need separate courses necessarily but that you might have different ways of approaching science more broadly* | **Science curriculum philosophy** | *Science education for future scientists vs everyday people | |
| *And so that was the basis for these two courses, Science in Society and Public Understanding of Science in Society and the whole of the trial by the QCA with the GCSE course 21st Century Science was based on their paper* | **Osbourne science curriculum philosophy in practice** | *Development of science curricula based Osbourne philosophy | |
| *So it was looking at how you might think about what science is for future scientists and non scientists* | **Osbourne science curriculum philosophy in practice** | *Science education for future scientists vs everyday people | |
| *And more recently I was involved, when I was working at the Nuffield Foundation, I was involved in the Royal Society of Biology and, in their working party looking at the looking at the content of the new curriculum* | **2010-2013 Revision** | Personal experience | |
| *Now the trouble is, when you're trying to develop a new curriculum, particularly in biology I think, there are a lot of professional bodies associated with every area of biology mycology, parasitology, ect. that think their content should be included in the school curriculum* | **Science curriculum development contributors** | *Professional bodies<br><br>*Who gets to contribute to the process of revision | |
| *And it's very difficult to get anybody who's capable of leading on the decisions that need to be made around what should and what should not be in the curriculum but I think there was a pretty big consensus that we needed to update the content around genetics* | **2010-2013 Revision** | *Who are the players/agents?<br><br>*Genetics in the curriculum | Who determined this consensus?<br><br>Why is it difficult? |
| *Even so there was a big debate about whether what you should need to know by the age of 16, which is the national curriculum, should you start with Mendelian genetics and get people to understand the mechanism of inheritance and then at advance level go on to talk about the more recent advances and the way we look at genomics, population studies or should you do it the other way around* | **Discussion amongst members of the 2011 National Curriculum Working Party** | *Scope and sequencing of Genetics lessons<br><br>*Where does Modern Genetics belong within the curriculum? Who should be the target audience? | |
| *We had arguments on both sides because you could start teaching genetics from looking at a population and the proportion of people with different attributes* | **Discussion amongst members of the 2011 National** | *Scope and Sequencing | The participant speaks as if there were only two solutions. I wonder if there |

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| *and so on but it's almost impossible to get fundamental changes* | **Curriculum Working Party** | *Frustration with the difficulty of changing the curriculum | were more options considered…<br><br>Curricular Inertia rears its head… |
| *I think people are strongly tied to what they learned at school and therefore what they think everybody should know and I don't think there's enough long-term ongoing debate between educationalists and scientists about what are the building blocks of the knowledge you need to work in that area* | **Aspects that affect science curriculum development** | *Observation of the effects of differing points of view on the curriculum | Characterizes this debate as being between the educationalists and scientists, who took which side? |
| *So we did get some changes and we were very strongly in touch with individuals with the Wellcome Trust who at the time was working on a big educational program for genomics in schools* | **Curriculum revision 2010-2013** | *Contributions of organizations to the revision | |
| *They were very articulate and managed to sort of convince people. It was kind of depressing that it hinges on individuals being able to argue the case rather than there being a proper process of what should be in the curriculum and how that decision is made* | **Curriculum revision 2010-2013** | Frustration with the lack of system/process for determining content | Wouldn't any system also rely on individuals making an argument? Wasn't the group the process? |
| *In the end there were some small changes, some allusions to genomics right down into the GCSE but you have to think "well what do teachers understand by this" and there wasn't any sort of program of professional development associated with this change* | **Curriculum dev** | *Teacher knowledge and curriculum development | |
| *So I don't know what's actually happening in schools and I haven't been as involved in directly in schools since that time but certainly there is a pretty good consensus that we needed to update the genetics contents and genetics topics* | **Curriculum dev** | *Connection between science curriculum and science teaching | How much does the NC dictate what's taught in classrooms? |
| *But I still think it's taught pretty traditional and genomics would be an extension of what we used to teach before which is one way of doing it* | **Genetics teaching** | *Addition of genomics knowledge to the curriculum | |
| *Well I think that's just about it. We did commission, when I was working in Nuffield, we did commission somebody to write some teaching materials which you probably would find actually still. I found some for this course the other day* | **Genetics teaching** | Teaching materials | |
| *If you search on Science for Public Understanding or Science in Society which is the most recent version and you look at resources you'll get to a page where you can look by topic and you will see* | **Teaching materials** | *Developed teaching materials | |

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| *some materials that were produced on large scale studies and I can't remember the exact topic but I think it was how they inform, yes they had a medical context* | | *Teaching genomics through medical application | |
| *I can't remember if it was drug development or looking at contributing factors to multifactorial diseases but there are resources* | **Teaching materials** | *Developed teaching materials<br><br>*Teaching genomics through medical application | |
| *But that course didn't actually last very long, because with the most recent changes in the curriculum it died a death and wasn't included in the new curriculum, we don't know how teachers got on with that particularly* | **Science in Society** | *What happened to genomics outreach after the 2010-2013 Revision | How did the changes in the NC lead to the demise of this course? |
| *Yes so the A-level course was piloted from 2004 and actually went public in 2006 but I'm not absolutely certain but that was called SNAB* | **SNAB** | *Timeline | |
| *So that course, SNAB, one of the things you had to do for the AS course, the lower 6th, or first first year of the study, was a visit or a report on an issue so people around sort of the area of Cambridge and that side of England did actually visit the Sanger Institute in Cambridge and they run outreach from there* | **SNAB** | *Contributors to Genomics teaching<br><br>*Course content | Sanger Institute in Cambridge |
| *In fact that's another thing, I know they are doing a lot of outreach but it tends to be local rather than national but they would be interested in talking to you if you wanted to give them a call* | **Sanger Institute** | *Public engagement and outreach | |
| *So some of the students will have visited and done their report on the visit and what the scientists say and while they're there they would have asked some questions but unless they did that special little study* | **SNAB** | *Student experience with contributors | |
| *I think that the influence of genomics would be fairly small even in these courses I'm talking about but at least there would have been an awareness that genetics isn't just about inherited diseases and eye color and gender….* | **Genomics in education** | *Influence on genetics teaching | |
| *Yes ok, that's a complex question because I think the driver is university entrance still*<br><br>*I think there's always lip service given to what employers say* | **Curriculum change** | *Influence of universities on curriculum change | How much do universities really influence change? There are often education academics present. |

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| *So whenever there's a change in the curriculum there's a lot of employers involved in having a chat about what is needed but in the end but our education system is driven by university entrance requirements and that is A-Levels and A-levels are designed according to what is needed by the universities for their undergraduate courses* | **Curriculum change** | *Influence of universities on curriculum change | University exams influence A Levels which then influence GCSE's |
| *So if you talk to people at universities you get some conflicting messages*<br><br>*Sometime they say, I've actually spoken to university lecturers who say "Just don't teach them too much about biochemistry for example because teachers get it wrong and they (students) have misconceptions when they come to university and what's really important is that they know how to learn and have study skills and that they have some practical skills and know how to carry out an investigation"* | **University preferences and Secondary Science** | *Scope and sequence<br><br>*Teaching science content knowledge vs science skills | |
| *And others I've spoken to say what's really important is that they have the building blocks of knowledge in place, that they know what a cell is and you shouldn't be talking to them about fancy stuff like genomics because they haven't got the fundamentals of what's in a cell and how the most simple biochemical pathways work* | **University preferences and Secondary science** | *Scope and sequence<br><br>*Depth vs breadth of content knowledge | |
| *So they're frustrated by the core knowledge which never adds up when you talk to people because if you look at what they're saying is lacking, it's actually present in the curriculum* | **Universities and Secondary science** | *Secondary science educator frustrations | |
| *So they say that students don't know about simple cell structures but why not? They've done it GCSE and they've done it at A-level so why don't they know it and I don't understand why they don't and it's usually things that are in the curriculum that they're complaining are not in the curriculum* | **Content knowledge** | *Secondary science educator frustrations<br><br>*Disconnect between what is taught and what is learned | |
| *So there's something about the way that students translate what they know when they get to a new course and studying it impacts differently for situated learning and they can't transpose it from one situation to another* | **Content knowledge** | *Exhibiting learning (Blooms Taxonomy?) | Is there a conflict here between what's learned and how to exhibit what's learned? |
| *But I think the main driver is university and employers* | **Curriculum change** | *Motivations/influence of Universities | |

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| *We've had dabbles in this country with vocational courses and an advanced diploma and that came to nothing and that's quite political* | ***Alternative secondary certificates** | *Different paths to achievement | |
| *It tends to be the right wing conservative government who didn't want the diploma and it sort of all crashed when they came back into power* | ***Alternative secondary certificates** | *Political opposition | Example of politics affecting change in education |
| *No originally after Tony Blair's and Gordon Brown's government so when Cameron came in so we've had them for a while now* | **Alternative secondary certificates** | *Timeframe | |
| *But there was a diploma development in the earlier part of this century sort of around, it must have been around 2007ish I think although I'm not sure about that but there were plans and a lot of money spent on the development of a science diploma and industry were very well represented to that but it came to nothing* | **Alternative secondary certificates** | *Development and consideration | |
| *But the driver, yes I don't think you could argue it's anything other than university because the GCSE has to feed A-Levels and A-Levels have to feed university* | **Curriculum change** | Motivations/influence of universities | |
| *If you look at the aims of the national curriculum they're broader than that but I think employment roots are secondary* | **Curriculum dev** | *Influences of employers | |
| *The most recent change in the curriculum, I don't know if you've looked at the one prior to 2014*<br><br>*The 2006 curriculum at key stage 4, there was a lot more content that was not factual so there was a lot more about applications and implications of science and the processes of science* | **Previous Curriculum (2006-2013)** | *Science content approach | |
| *What we've returned to is a much more traditional curriculum with a lot more factual knowledge* | **Current curriculum** | *Science content approach | |
| *There's a tension there you could say*<br><br>*I've heard Michael Gove, the previous secretary of state for education, he says that if you're talking about access it's not fair to give some people knowledge and not others* | **Science content knowledge and access** | *Broader social implications/gatekeeping | This is a political argument but does it represent an actual education policy (Field of Production) |
| *In other words you should have a very fact based curriculum because that gives people the root out of their socioeconomic position in society* | **Science content knowledge and access** | *Broader social implications/gatekeeping | Do they really think this or is it an argument of convenience? |
| *And I don't know*<br><br>*On the other hand, if you're turning off a whole load of people to science because it's very fact* | **Science content and access** | *Broader social implications/gatekeeping | |

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| *based and it doesn't connect with their lives then that's also an issue* | | | |
| *I don't see it as a polarized dichotomy myself*<br><br>*I see it as something that you can, whatever the curriculum, you can teach it in different ways and you can use context and applications* | **Science content and access** | *Science teaching approach<br><br>*Connections between curriculum and teaching | |
| *But it's whether genomics should be something that's assessed I mean that's what it comes down to, whether it's assessed or whether it's a context* | **Genomics knowledge** | *Influence of assessment | Some may ask if there is a point to teaching things that won't be assessed |
| *So with the most recent curriculum they tried to…*<br><br>*There's somebody called Tim Oates, you might want to look at his paper called, I think it's called "Could Do Better"* | **Curriculum Literature** | *Tim Oates | |
| *He talks about how context should not be written in the curriculum and that the curriculum should be pure and that context should be something is something that you add as a teacher* | **Science curriculum philosophy** | *Role of context in curriculum development | |
| *He heavily influenced the most recent version of the curriculum* | **Curriculum revision 2010-2013** | *Tim Oates | |
| *You could argue that they need to know and be assessed on Mendelian genetics but genomics is a way of motivating students to learn about genetics because you can see all the wider applications of genetics as a science* | **Genetics ed and assessment** | *The place of genomics in a Mendelian genetics curriculum | |
| *So there are two ways of arguing it*<br><br>*You could say we need to introduce more cutting edge science into the curriculum and that needs to be assessed but if you put something in you have to take something out otherwise you overload the curriculum* | **Science curriculum philosophy** | *Classical science concepts vs Modern science concepts | |
| *That's an issue I have been involved in because when you develop a context lead course, you have to take out some of the curriculum content that people think of as essential to an A-level course or a GCSE course* | **Science curriculum philosophy** | *Context lead courses<br><br>*Determining what is in and out | This sounds a bit like interpreting the curriculum (the role of assessment)<br><br>Field of Production |
| *But you've got to make time for this sort of discussions and problem solving that is involved if you're trying to develop skills and understanding of how science is applied* | **Science curriculum development** | *Practical elements of teaching science application<br><br>*Curriculum and time restraints | |

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| *So ok the previous curriculum changes after 2000, for sciences just only, were based on a proposal to the QCA by the authors of the Beyond 2000 report and it was a very adventurous trial of a very different sort of course* | **Curriculum revision 2006** | *Processes and timeline | |
| *I would say there is a sort of almost (looking for words) drive from the academic education community there saying we thought really hard about what science education is for and who it's for* | **Curriculum revision 2006** | *Consideration of appropriate audience | Field of Production |
| *And that was taken up by because of the people who were at the QCA at the time, which was a non-governmental organization (NGO)*<br><br>*Yes so it wasn't a governmental department but they were/had a direct line of access to the civil servants* | **Curriculum revision 2006** | *Quality Curriculum Authority (QCA) make-up and influence | So an NGO had direct access to the ultimate writers of the curriculum at the time |
| *So the conservatives closed QCA when they came in, it doesn't exist now and so the most recent curriculum change, it's difficult to say who drove it* | **Curriculum revision 2010-2013** | *Political influence on curriculum | |
| *They were happy for the three professional bodies, The Royal Society of Chemistry, the Institute of Physics, and the then Society of Biology which is now the Royal Society of Biology, to take a lead* | **Curriculum revision 2010-2013** | *Contributors to the 2010-2013 Revision<br><br>*Role of the Learned Societies | New agents/players |
| *There was a policy group called Science Communities Representing Education (SCORE) which consisted of those professional bodies plus the Association for Science Education and the Science Counsel* | **SCORE** | *Outside groups influencing curriculum development | |
| *They used to meet and it became a group of representatives from those organizations that did have a direct influence on policy* | **SCORE** | *Outside groups influencing curriculum development | |
| *So civil servants would to talk to SCORE if they wanted to have a view on science education* | **SCORE** | *Outside groups influencing curriculum development<br><br>*Civil service interactions | |
| *Whether that was a good idea or not I don't know because it took the science education academics out of the loop and the quality of the discussion was reliant on the individuals who represented the IoP and the SoB and to some extent they weren't necessarily educationalists* | **SCORE** | *Outside groups influencing curriculum development<br><br>*Frustration with lack of academic influence | This represents a division of knowledgeable science |

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| *So it was sometimes good it was sometimes very poor indeed* | **SCORE** | *Outside groups influencing curriculum development | |
| *So when the new curriculum came up it seemed the obvious thing to say (was) that the 3 bodies will develop the physics, chemistry, and biology curricula and try and consult on things that they share* | **Curriculum revision 2011** | *Contributors to the 2010-2013 Revision<br><br>*Role of the Learned Societies | |
| *It was very clear that the physical scientists and the biologists disagreed immediately about the content in terms of the additional content about applications and implications* | **Curriculum revision 2011** | *Working group conflicts | |
| *The physicists saw that as diluting the curriculum and the biologists were keen to keep the ethics* | **Curriculum revision 2011** | *Working group conflicts | |
| *In fact the word ethics is still there once I think in the key stage 4 curriculum, and the chemistry lot was somewhere in between* | **Curriculum revision 2011** | *Working group conflicts and outcomes | |
| *The individuals who (were) appointed by the professional bodies to do this curriculum development were people who had time to do so they weren't employed by those professional bodies and again they weren't the right people in my view to do that, it should have been a more consultative process* | **Curriculum revision 2011** | *Working group participants/dynamic | Doesn't consider the process to have been consultative<br><br>First mentions of the Curriculum drafters and the role they played |
| *So the physicist was Paul Black who was very imminent scientist*<br><br>*Yes Paul Black from Assessment for Learning* | **Curriculum revision 2011** | *Curriculum Drafters (Physics writer) | |
| *He's a great guy but he just did it all on his own, he wrote the physics curriculum and that's not the way to do it* | **Curriculum revision 2011** | *Working group dynamic | Doesn't describe a collaborative process |
| *The chemist was also not thought of as the right person* | **Curriculum revision 2011** | *Curriculum Drafter (Chemistry writer) | |
| *The biology person was the author of textbooks so she had been a teacher but she isn't an education academic* | **Curriculum revision 2011** | *Curriculum Drafter (Biology writer) | Shows a real preference for educational academia as opposed to educationalists in general |
| *And she's written good textbooks but they're very traditional and she took this on and has the time to do it but again you could argue she wasn't the right person* | **Curriculum revision 2011** | *Curriculum Drafter (Biology writer) | Even feels someone with a background in science education wasn't appropriate |

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| | | | Participant's preference for "non-traditional" approaches shows |
| *She didn't' have a deep understanding of curriculum development and the people who did probably weren't available to do that work* | **Curriculum revision 2011** | *Curriculum Drafter (Biology writer)<br><br>*Availability of qualified | But she did understand biology communication<br><br>Another mention of availability |
| *We used to meet at the Royal Society of Biology and there was a representative from partner organizations who had an education people* | **Curriculum revision 2011** | *Working group dynamic/process | |
| *So for example the biochemical society has an education coordinator so they would come*<br><br>*The physiology society, the society of general microbiology, etc…* | **Curriculum revision 2011** | *Contributors to the 2010-2013 Revision<br><br>*Role of the Learned Societies | |
| *These people sent their representatives their representatives to be part of this so called "dialogue" about how the curriculum should be* | **Curriculum revision 2011** | *Working group processes/dyna mics<br><br>*Frustration with discourse | So called? |
| *Again, they were people who were working in outreach for their subject area* | **Curriculum revision 2011** | *Working group makeup | Science outreach vs Science education |
| *They weren't specialists in curriculum development and they didn't have that experience* | **Curriculum revision 2011** | *Working group makeup | |
| *They also didn't know about educational research and what research tells us about the order you should teach things in, the way you can build up a curriculum, etc* | **Curriculum revision 2011** | *Working group makeup | The argument could be made that isn't why they were there… |
| *So it was quite a…..*<br><br>*It wasn't a terribly coherent discussion I would say* | **Curriculum revision 2011** | *Working group processes/dyna mics<br><br>*Frustration with discourse | |
| *But people were asked to express their views and these leads went away and wrote what they'd thought we'd said and we argued a bit more about it* | **Curriculum revision 2011** | *Working group dynamic | She perceives the writers as having significant influence |
| *But then it went to the Dept. of Education and it came back as it is now so a lot of what we talked about wasn't really acknowledged* | **Curriculum revision 2011** | *Process vs. final results | |
| *Yes, so it had to be much more factual than we were hoping* | **Curriculum revision 2011** | *Differences between 2007 and 2016 Curricula | Consistent with Conservative Manifesto's pledge of a knowledge strong curriculum |
| *You couldn't have, for example, learning outcomes that were around ethical arguments that* | **Curriculum revision 2011** | *Differences between 2007 | |

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| *applied to a lot of different issues in biology* | | and 2016 Curricula | |
| *There is a lot in the previous curriculum around the development of science* | **Curriculum 2007-2013** | *Differences between 2007 and 2016 Curricula | |
| *It's almost the philosophy of science really and the nature of science but that's really been cut back so you're really down to the learning outcomes that are around curriculum topics* | **Curriculum 2007-2013** | *Differences between 2007 and 2016 Curricula | Content must be convenient to assess |
| *So that's what the process is, it goes to civil servants who then act on what they're told by the MP's in terms of what the policy is* | **Curriculum development** | *Process | |
| *So the policy comes ahead of being informed by either research or experts in the field talking* | **Curriculum development** | *Influence of Policy and research | Very much a Top Down process |
| *And they say it's evidence based but they do all this international comparative work and they look at the countries that are doing well* | **Curriculum development** | *Influence of policy and research | How much is the evidence used? |
| *Tim Oates actually does, when you read his paper he does understand how you should be looking at international comparisons, but I think the government (MP's) just get the headlines "That's Country's Doing Well" so we should be like them* | **Curriculum development** | *International comparisons and research | Can be seen as a very policymaker approach |
| *It may be peculiar as I don't know if it's the same in America but the civil servants change jobs fairly regularly so they are sent to the Dept for Education and then, after maybe 3 or 4 years, they may be sent to a completely different dept*<br><br>*So again they're not specialists in education* | **Civil service** | *Shifting workforce dynamics | Changing governments with different philosophies can't help either |
| *They tend to then commission the odd expert, they choose people who have the kind of political agreement with their policies as their experts so to reinforce* | **Policymaking** | *Role of experts | So is the best way to obtain capital for an expert to align their research with a political viewpoint? |
| *They will only ask people who reinforce what they're thinking anyway but it's quite difficult to push against that* | **Policymaking** | *Role of experts | Is this how policymakers develop discourse around a subject? |
| *There's an increasing cynicism about educational research and its role* | **Ed research** | *Role in policymaking | |
| *It's difficult because you've honed in a one subject here which is genomics but in a way it illustrates some broader things about whether context or content should lead* | **Science Education** | *Philosophical approach | |

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| *There's been a lot of work on context lead courses here with the Salters courses, Judith Bennett is the author who's written a lot about those* | **Science Education** | *Modern approaches | |
| *And there's been a lot of talk about getting cutting edge science into the curriculum to make it seem more relevant* | **Science Education** | *Modern science in the curriculum | |
| *And I think the feeling on the cutting edge science is that you shouldn't try and be too cutting edge because things change so quickly* | **Science Education** | *Modern science in the curriculum | |
| *So when Dolly the sheep was cloned, it was in all the textbooks* | **Science Education** | *Modern science in the curriculum | Specific example |
| *But of course it became very old hat after 3 years, I can't remember how long she lived, not that long, but she died and then it was really the most recent bit of news but you've got it stuck in your textbooks so people are now saying perhaps we should stick with the fundamentals of science and then you can still use things from the newspaper or websites but don't start having Dolly the Sheep as something you examine because it will go out of date so quickly* | **Science Education** | *Modern science in the curriculum | Specific example |
| *The only thing I doubt is my background is educational design and I think it's not something that's considered an academic area of study in this country whereas it is in the states and it is Europe* | **Personal experience** | *Background | |
| *So I think we suffer from that and we're not very good at developing curricula* | **English National Education** | *Deficiencies | |
| *And if you think of the work that's been done by the AAS in the states, they poured millions, I don't know how much all that cost but it's an awful lot of money isn't? Probably thousands of thousands, maybe millions actually and I don't think we can really replicate that work and it seems very odd to me that we don't sometimes look at that* | **Education Research** | *Research in the US vs Europe<br><br>*International comparisons | |
| *But that whole area of curriculum development, there's no proper process in the country I would say* | **Curriculum development in the UK** | *Process (lack thereof) | |
| *(Maybe) the process should not be policy or that the policy should be to leave curriculum developers to do the job<br><br>That could be a policy* | **Curriculum development in the UK** | *Process | |
| *The mp's, for example, and current government they learned long division when they were 8 and they think every 8 year old should learn long division* | **Curriculum development in the UK** | *Political influence as a limiting factor | |

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| *And they have limited experience but they have a view on education that isn't terribly well informed and the policies sometimes doesn't really chime with what educational research tells you* | **Curriculum development in the UK** | *Political influence as a limiting factor | |

Appendix E: Pedagogic Device and Timeline Coding Scheme Ginny W

| What did they say? (Utterance) | Field Represented Production Recontext(ORF,PRF) Reproduction | Timeframe General, Prior to 2010-2013 Revision, During 2010-2013 Revision, Post 2010-2013 Revision | Comments |
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| My experience that is relevant to this is in the discussion around in the most recent changes in the national curriculum but also in curriculum development which wasn't so tied to the existing national curriculum before that so I'll talk about those separately | Recontext ORF,PRF | Prior | |
| So prior to this last curriculum I was involved in the development of an A-Level course called Salters-Nuffield Advanced Biology, or SNAB, and also a course which the Qualifications and Curriculum Authority (QCA) that existed in those days, this is back in 2004-2006 | Reproduction/ Recontext PRF | Prior | Recontext- she helped to develop a class that recont. some aspects of science knowledge<br><br>SALTERS-NUFFIELD (PRF) |
| They (QCA) piloted a new GCSE course called 21 Century Science, so I was involved in the development of that | Reproduction | Prior | 21st Century Science is now OCR Science and has been changed |
| So the first one, the A-Level course which I became involved in in the year 2000 we looked at what an A-Level should contain and we basically had to cover what was in the Key Stage 5 curriculum but we had a lot of scope outside of that | Reproduction | Prior | |
| It's a context lead course so we can introduce material which is about the story of why you're | Reproduction/ Recontext PRF | Prior | |

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| learning the facts that are in the curriculum and we took the view that you should introduce cutting edge science so we did introduce genomics quite lightly | | | |
| We introduced it as a concept, we introduced the idea of large scale studies which other A-Level biology courses hadn't necessarily addressed at that point | Reproduction/ Recontext PRF | Prior | |
| So we looked at it through the context of health and multifactorial diseases and then we looked at genomics and genetics in terms of biodiversity, another topic, so we looked at how you can map pedigrees and use that for example to conservation | Reproduction/ Recontext PRF | Prior | |
| And we also had a whole topic called the Voice of the Genome which is looking at development | Reproduction/ Recontext PRF | Prior | |
| And so we didn't take the traditional approach genetics, teaching Mendelian genetics and then sort of moving on to an application | Reproduction/ Recontext PRF | Prior | |
| We actually took these contexts and looking at the relevance of advances in genetics research to those topics | Reproduction/ Recontext PRF | Prior | |
| And then in the 21st Century Science development which was for younger pupils we took the same approach really, we did look at how you map, how you run analyses of genomes and looked at large scale studies | Reproduction/ Recontext PRF | Prior | |
| I should also mention there was a course prior to that earlier than either of those two which was called Science in Society. That was an A-Level course | Reproduction | Prior | |

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| AS which is just the first half of A-Level so you could only do it as a sort of add on to A-Levels and it was intended for either students studying science who wanted to broaden their science education to more societal issues or the non scientist who wanted to keep some science going but not necessarily studying science at a more advanced level but looking at it broadly | Reproduction | General | |
| And those, that course, both of them, particularly the most recent one where we had A-Level, again it looked at the influence of multifactorial influences on health, disease, lifestyle and looked at how you can measure the genome, how you can map it, the sort of studies that help to determine what advice to give people and also for drug development, there's a whole section on drug development | Reproduction/ Recontext PRF | Prior | |
| And we talked about personalized medicine, that sort of thing, that was sort of the topic | Reproduction/ Recontext PRF | Prior | |
| So have you read the study called "Beyond 2000"?<br><br>So in 1998 there was a big study or a paper by Robin Miller and Jonathan Osbourne, | Reproduction/ Recontext PRF | Prior | |
| Jonathan has done a lot of work on the curriculum in the states, and they weren't the first people to say this but they basically put together an argument that the current science education, at the time, was suitable for future scientists but it wasn't | Reproduction | Prior | |

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| suitable for people who aren't going on to be future scientists and as most pupils, the vast majority of pupils are not going to be scientists, is this curriculum fit for purpose? | | | |
| So they discussed in the paper, which is easily accessible online, they discussed the sort of things that might be introduced into courses that were more for to broaden the range of interest in science | Recontext PRF | Prior | |
| Now, they didn't at that point argue that you need separate courses necessarily but that you might have different ways of approaching science more broadly | Reproduction | Prior | |
| And so that was the basis for these two courses, Science in Society and Public Understanding of Science in Society and the whole of the trial by the QCA with the GCSE course 21st Century Science was based on their paper | Recontext PRF | Prior | |
| So it was looking at how you might think about what science is for future scientists and non scientists | Recontext PRF | Prior | |
| And more recently I was involved, when I was working at the Nuffield Foundation, I was involved in the Royal Society of Biology and, in their working party looking at the looking at the content of the new curriculum | Recontext ORF | During | |
| Now the trouble is, when you're trying to develop a new curriculum, particularly in biology I think, there are a lot of professional bodies associated with every area of biology | Recontext ORF, Production | During | Recontext- statement is about the revision process |

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| mycology, parasitology, ect. that think their content should be included in the school curriculum | | | Production- reveals a bit about how the players of that field go on to influence recontext |
| And it's very difficult to get anybody who's capable of leading on the decisions that need to be made around what should and what should not be in the curriculum but I think there was a pretty big consensus that we needed to update the content around genetics | Recontext ORF | During | |
| Even so there was a big debate about whether what you should need to know by the age of 16, which is the national curriculum, should you start with Mendelian genetics and get people to understand the mechanism of inheritance and then at advance level go on to talk about the more recent advances and the way we look at genomics, population studies or should you do it the other way around | Recontext ORF | During | |
| We had arguments on both sides because you could start teaching genetics from looking at a population and the proportion of people with different attributes and so on but it's almost impossible to get fundamental changes | Recontext ORF | Prior | |
| I think people are strongly tied to what they learned at school and therefore what they think everybody should know and I don't think there's enough long term ongoing debate between educationalists and scientists about what are | Production, Reproduction | General | |

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| the building blocks of the knowledge you need to work in that area | | | |
| So we did get some changes and we were very strongly in touch with MH with the Wellcome Trust who at the time was working on a big educational program for genomics in schools | Recontext ORF | During | |
| He was very articulate and managed to sort of convince people. It was kind of depressing that it hinges on individuals being able to argue the case rather than there being a proper process of what should be in the curriculum and how that decision is made | Recontext ORF | During | |
| In the end there were some small changes, some allusions to genomics right down into the GCSE but you have to think "well what do teachers understand by this" and there wasn't any sort of program of professional development associated with this change | Recontext ORF, PRF | During, Post | During-outcomes of the revision are mentioned<br><br>Post-after the revision ended there was little support in the form of PD |
| So I don't know what's actually happening in schools and I haven't been as involved in directly in schools since that time but certainly there is a pretty good consensus that we needed to update the genetics contents and genetics topics | Reproduction | Post | |
| But I still think it's taught pretty traditionally and genomics would be an extension of what we used to teach before which is one way of doing it | Reproduction | Post | |
| Well I think that's just about it. We did commission, when I was working in Nuffield, we did commission | Reproduction | Prior | |

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| somebody to write some teaching materials which you probably would still find actually. I found some for this course the other day | | | |
| If you search on Science for Public Understanding or Science in Society which is the most recent version and you look at resources you'll get to a page where you can look by topic and you will see some materials that were produced on large scale studies and I can't remember the exact topic but I think it was how they inform, yes they had a medical context | Reproduction | Post | |
| I can't remember if it was drug development or looking at contributing factors to multifactorial diseases but there are resources | Reproduction | Post | |
| But that course didn't actually last very long, because with the most recent changes in the curriculum it died a death and wasn't included in the new curriculum, we don't know how teachers got on with that particularly | Reproduction | Post | |
| Yes so the A-level course was piloted from 2004 and actually went public in 2006 but I'm not absolutely certain but that was called SNAB | Reproduction | Prior | |
| So that course, SNAB, one of the things you had to do for the AS course, the lower 6th, or first year of the study, was a visit or a report on an issue so people around sort of the area of Cambridge and that side of England did actually visit the Sanger Institute in Cambridge and they run outreach from there | Reproduction | Prior | |

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| In fact that's another thing, I don't know how much I have about it to say at the moment as I'm actually on the advisory committee for educational outreach for the Sanger Center and I know they are doing a lot of outreach but it tends to be local rather than national but they would be interested in talking to you if you wanted to give them a call | Reproduction | Post | |
| So some of the students will have visited and done their report on the visit and what the scientists say and while they're there they would have asked some questions but unless they did that special little study | Reproduction | Prior | |
| I think that the influence of genomics would be fairly small even in these courses I'm talking about but at least there would have been an awareness that genetics isn't just about inherited diseases and eye color and gender…. | Reproduction | Prior | |
| Yes ok, that's a complex question because I think the driver is university entrance still<br><br>I think there's always lip service given to what employers say | Recontext ORF | General | Asked about what drives curriculum change |
| So whenever there's a change in the curriculum there's a lot of employers involved in having a chat about what is needed but in the end but our education system is driven by university entrance requirements and that is A-Levels and A-levels are designed according to what is needed by the universities for their undergraduate courses | Recontext ORF | General | |

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| So if you talk to people at universities you get some conflicting messages<br><br>Sometime they say, I've actually spoken to university lecturers who say "Just don't teach them too much about biochemistry for example because teachers get it wrong and they (students) have misconceptions when they come to university and what's really important is that they know how to learn and have study skills and that they have some practical skills and know how to carry out an investigation" | Recontext ORF | General | |
| And others I've spoken to say what's really important is that they have the building blocks of knowledge in place, that they know what a cell is and you shouldn't be talking to them about fancy stuff like genomics because they haven't got the fundamentals of what's in a cell and how the most simple biochemical pathways work | Recontext ORF | General | |
| So they're frustrated by the core knowledge which never adds up when you talk to people because if you look at what they're saying is lacking, it's actually present in the curriculum | Reproduction | General | |
| So they say that students don't know about simple cell structures but why not? They've done it GCSE and they've done it at A-level so why don't they know it and I don't understand why they don't and it's usually things that are in the curriculum that they're | Reproduction | General | |

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| complaining are not in the curriculum | | | |
| So there's something about the way that students translate what they know when they get to a new course and studying it impacts differently for situated learning and they can't transpose it from one situation to another | Reproduction | General | |
| But I think the main driver is university and employers | Recontext ORF | General | |
| We've had dabbles in this country with vocational courses and an advanced diploma and that came to nothing and that's quite political | Reproduction | Prior | |
| It tends to be the right wing conservative government who didn't want the diploma and it sort of all crashed when they came back into power | Reproduction | Prior | |
| No originally after Tony Blair's and Gordon Brown's government so when Cameron came in so we've had them for a while now | Reproduction | Prior | |
| But there was a diploma development in the earlier part of this century sort of around, it must have been around 2007ish I think although I'm not sure about that but there were plans and a lot of money spent on the development of a science diploma and industry were very well represented to that but it came to nothing | Reproduction | Prior | |
| But the driver, yes I don't think you could argue it's anything other than university because the GCSE has to feed A-Levels and A-Levels have to feed university | Recontext ORF | General | |
| If you look at the aims of the national curriculum they're broader than that but I think | Recontext ORF | General | |

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| employment roots are secondary | | | |
| The most recent change in the curriculum, I don't know if you've looked at the one prior to 2014<br><br>The 2006 curriculum at key stage 4, there was a lot more content that was not factual so there was a lot more about applications and implications of science and the processes of science | Recontext ORF | Prior | |
| What we've returned to is a much more traditional curriculum with a lot more factual knowledge | Recontext ORF | Post | |
| There's a tension there you could say<br><br>I've heard Michael Gove, the previous secretary of state for education, he says that if you're talking about access it's not fair to give some people knowledge and not others | Recontext ORF | General | |
| In other words you should have a very fact based curriculum because that gives people the root out of their socioeconomic position in society | Recontext ORF | General | |
| And I don't know<br><br>On the other hand, if you're turning off a whole load of people to science because it's very fact based and it doesn't connect with their lives then that's also an issue | Recontext ORF | General | |
| I don't see it as a polarized dichotomy myself<br><br>I see it as something that you can, whatever the curriculum, you can teach it in different ways and you can use context and applications | Reproduction | General | |

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| But it's whether genomics should be something that's assessed I mean that's what it comes down to, whether it's assessed or whether it's a context | Reproduction | General | Determining how students exhibit learning occurs on the field of reproduction |
| So with the most recent curriculum they tried to…<br><br>There's somebody called Tim Oates, you might want to look at his paper called, I think it's called "Could Do Better" | Reproduction | Prior | TIM OATES |
| He talks about how context should not be written in the curriculum and that the curriculum should be pure and that context should be something is something that you add as a teacher | Reproduction | General | |
| He heavily influenced the most recent version of the curriculum | Recontext ORF | During | TIM OATES |
| You could argue that they need to know and be assessed on Mendelian genetics but genomics is a way of motivating students to learn about genetics because you can see all the wider applications of genetics as a science | Reproduction | Post | |
| So there are two ways of arguing it<br><br>You could say we need to introduce more cutting edge science into the curriculum and that needs to be assessed but if you put something in you have to take something out otherwise you overload the curriculum | Recontext ORF | General | |
| That's an issue I have been involved in because when you develop a context lead course, you have to take out some of the curriculum content that people think of as | Recontext PRF | During | |

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| essential to an A-level course or a GCSE course | | | |
| But you've got to make time for this sort of discussions and problem solving that is involved if you're trying to develop skills and understanding of how science is applied | Recontext ORF | During | |
| So ok the previous curriculum changes after 2000, for sciences just only, were based on a proposal to the QCA by the authors of the Beyond 2000 report and it was a very adventurous trial of a very different sort of course | Recontext ORF | Prior | |
| I would say there is a sort of almost (looking for words) drive from the academic education community there saying we thought really hard about what science education is for and who it's for | Recontext ORF | Prior | |
| And that was taken up because of the people who were at the QCA at the time, which was a non-governmental organization (NGO)<br><br>Yes so it wasn't a governmental department but they were/had a direct line of access to the civil servants | Recontext PRF | Prior | |
| So the Conservatives closed QCA when they came in, it doesn't exist now and so the most recent curriculum change, it's difficult to say who drove it | Recontext ORF | Prior | |
| They were happy for the three professional bodies, The Royal Society of Chemistry, the Institute of Physics, and the then Society of Biology which is now the Royal Society of Biology, to take a lead | Recontext ORF | During | |

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| There was a policy group called Science Communities Representing Education (SCORE) which consisted of those professional bodies plus the Association for Science Education and the Science Counsel | Recontext PRF | Prior | |
| They used to meet and it became a group of representatives from those organizations that did have a direct influence on policy | Recontext ORF | Prior | |
| So civil servants would to talk to SCORE if they wanted to have a view on science education | Recontext ORF | Prior | |
| Whether that was a good idea or not I don't know because it took the science education academics out of the loop and the quality of the discussion was reliant on the individuals who represented the IoP and the SoB and to some extent they weren't necessarily educationalists | Recontext ORF | Prior | |
| So it was sometimes good it was sometimes very poor indeed | Recontext ORF | Prior | |
| So when the new curriculum came up it seemed the obvious thing to say (was) that the 3 bodies will develop the physics, chemistry, and biology curricula and try and consult on things that they share | Recontext ORF | During | |
| It was very clear that the physical scientists and the biologists disagreed immediately about the content in terms of the additional content about applications and implications | Recontext ORF | During | |
| The physicists saw that as diluting the curriculum and the biologists were keen to keep the ethics | Recontext ORF | During | |

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| In fact the word ethics is still there once I think in the key stage 4 curriculum, and the chemistry lot was somewhere in between | Reproduction ORF | Post | |
| The individuals who (were) appointed by the professional bodies to do this curriculum development were people who had time to do so they weren't employed by those professional bodies and again they weren't the right people in my view to do that, it should have been a more consultative process | Recontext ORF | During | |
| So the physicist was Paul Black who was very imminent scientist<br><br>Yes Paul Black from Assessment for Learning | Recontext ORF | During | |
| He's a great guy but he just did it all on his own, he wrote the physics curriculum and that's not the way to do it | Recontext ORF | During | |
| The chemist was also not thought of as the right person | Recontext ORF | During | |
| The biology person was the author of text books so she had been a teacher but she isn't an education academic | Recontext ORF | During | |
| And she's written good text books but they're very traditional and she took this on and has the time to do it but again you could argue she wasn't the right person | Recontext ORF | During | |
| She didn't' have a deep understanding of curriculum development and the people who did probably weren't available to do that work | Recontext ORF | During | |
| We used to meet at the Royal Society of Biology and there was a representative from partner organizations who had an education people | Recontext ORF | During | |

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| So for example the biochemical society has an education coordinator so they would come<br><br>The physiology society, the society of general microbiology, etc… | Recontext ORF | During | |
| These people sent their representatives to be part of this so called "dialogue" about how the curriculum should be | Recontext ORF | During | |
| Again, they were people who were working in outreach for their subject area | Recontext ORF | During | |
| They weren't specialists in curriculum development and they didn't have that experience | Recontext ORF | During | |
| They also didn't know about educational research and what research tells us about the order you should teach things in, the way you can build up a curriculum, etc | Recontext ORF | During | |
| It wasn't a terribly coherent discussion I would say | Recontext ORF | During | |
| But people were asked to express their views and these leads went away and wrote what they'd thought we'd said and we argued a bit more about it | Recontext ORF | During | |
| But then it went to the Dept. of Education and it came back as it is now so a lot of what we talked about wasn't really acknowledged | Recontext ORF | Post | |
| Yes, so it had to be much more factual than we were hoping | Recontext ORF | Post | |
| You couldn't have, for example, learning outcomes that were around ethical arguments that applied to a lot of different issues in biology | Recontext ORF | Post | |

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| There is a lot in the previous curriculum around the development of science | Recontext ORF | Prior | |
| It's almost the philosophy of science really and the nature of science but that's really been cut back so you're really down to the learning outcomes that are around curriculum topics | Recontext ORF | Prior | |
| So that's what the process is, it goes to civil servants who then act on what they're told by the MP's in terms of what the policy is | Recontext ORF | General | |
| So the policy comes ahead of being informed by either research or experts in the field talking | Recontext ORF | General | |
| And they say it's evidence based but they do all this international comparative work and they look at the countries that are doing well | Recontext ORF | General | |
| Tim Oates actually does, when you read his paper, he does understand how you should be looking at international comparisons, but I think the government (MP's) just get the headlines "That's Country's Doing Well" so we should be like them | Recontext ORF | During | |
| It may be peculiar. I don't know if it's the same in America but the civil servants change jobs fairly regularly so they are sent to the Dept for Education and then, after maybe 3 or 4 years, they may be sent to a completely different dept<br><br>So again they're not specialists in education | Recontext ORF | General | |

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| They tend to then commission the odd expert, they choose people who have the kind of political agreement with their policies as their experts so to reinforce | Recontext ORF | General | |
| They will only ask people who reinforce what they're thinking anyway but it's quite difficult to push against that | Recontext ORF | General | |
| There's an increasing cynicism about educational research and its role | Recontext ORF | General | |
| It's difficult because you've honed in a one subject here which is genomics but in a way it illustrates some broader things about whether context or content should lead | Recontext ORF | General | |
| There's been a lot of work on context lead courses here with the Salters courses, Judith Bennett is the author who's written a lot about those | Reproduction | General | |
| And there's been a lot of talk about getting cutting edge science into the curriculum to make it seem more relevant | Recontext ORF, PRF | General | |
| And I think the feeling on the cutting edge science is that you shouldn't try and be too cutting edge because things change so quickly | Recontext ORF, PRF | General | |
| So when Dolly the sheep was cloned, it was in all the textbooks | Recontext ORF, Production | Prior | |
| But of course it became very old hat after 3 years, I can't remember how long she lived, not that long, but she died and then it was really the most recent bit of news but you've got it stuck in your textbooks so people are now saying perhaps we should stick with the | Recontext ORF | Prior | |

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| fundamentals of science and then you can still use things from the newspaper or websites but don't start having Dolly the Sheep as something you examine because it will go out of date so quickly | | | |
| The only thing I doubt is… My background is educational design and I think it's not something that's considered an academic area of study in this country whereas it is in the states and it is Europe | Reproduction | Post | |
| So I think we suffer from that and we're not very good at developing curricula | Recontext ORF | General | |
| And if you think of the work that's been done by the AAS in the states, they poured millions, I don't know how much all that cost but it's an awful lot of money isn't? Probably thousands of thousands, maybe millions actually and I don't think we can really replicate that work and it seems very odd to me that we don't sometimes look at that | Recontext ORF | General | |
| But that whole area of curriculum development, there's no proper process in the country I would say | Recontext ORF | General | |
| (Maybe) the process should not be policy or that the policy should be to left to curriculum developers to do the job<br><br>That could be a policy | Recontext ORF | General | |
| The MP's, for example, and current government they learned long division when they were 8 and they think every 8 year old should learn long division | Reproduction | General | |
| And they have limited experience but they have a view on education that | Reproduction | General | |

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| isn't terribly well informed and the policies sometimes doesn't really chime with what educational research tells you | | | |

Appendix F: Identifying Agents Coding Scheme Ginny W

| Reference Number | What did they say? (Utterance) | Agents | Notes (What can be inferred from what was said?) |
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| GW1 | And more recently I was involved, when I was working at the Nuffield Foundation, I was involved in the Royal Society of Biology and, in their working party looking at the looking at the content of the new curriculum | Learned Societies (Biology), Ed. Organizations (Nuffield Foundation) | Participated in the revision as a member of the RSB as opposed to a member of NOWGEN |
| GW2 | Now the trouble is, when you're trying to develop a new curriculum, particularly in biology I think, there are a lot of professional bodies associated with every area of biology mycology, parasitology, ect. that think their content should be included in the school curriculum | Academic Scientists, Industry Scientists | Each player has differing interest and the means to achieve said interest can be difficult to come by |
| GW3 | And it's very difficult to get anybody who's capable of leading on the decisions that need to be made around what should and what should not be in the curriculum but I think there was a pretty big consensus that we needed to update the content around genetics | Academic Scientists, Industry Scientists | Dean T also speaks to these difficulties |
| GW4 | I think people are strongly tied to what they learned at school and therefore what they think everybody should know and I don't think there's enough long term ongoing debate between educationalists and scientists about what are the building blocks of the knowledge you need to work in that area | Education Academics, Teachers, Academic Scientists, Industry Scientists | It would seem this particular forum would be the place to have that debate but the time restraints may be impeding progress on this front |
| GW5 | So we did get some changes and we were very strongly in touch with MH with the Wellcome Trust who at the time was working on a big educational program for genomics in schools | Wellcome Trust, NOWGEN | Who is we? The Working Group? The RSB? The program mentioned is the Genomics for Schools Program at NOWGEN funded by the Wellcome Trust |
| GW6 | He was very articulate and managed to sort of convince people. It was kind of depressing that it hinges on individuals being able to argue the case rather than there being a proper process of what should be in the curriculum and how that decision is made | Wellcome Trust, NOWGEN | Mentions the lack of process and some of the decision-making |
| GW7 | In the end there were some small changes, some allusions to genomics right down into the GCSE but you have to think "well what do teachers understand by this" and there wasn't any sort of program of professional development associated with this change | Teachers | How did teachers respond to this particular argument? |

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| GW8 | So whenever there's a change in the curriculum there's a lot of employers involved in having a chat about what is needed but in the end but our education system is driven by university entrance requirements and that is A-Levels and A-levels are designed according to what is needed by the universities for their undergraduate courses | Industry scientist, Universities | Doesn't mention this being the case in this particular instance |
| GW9 | There's a tension there you could say<br><br>I've heard Michael Gove, the previous secretary of state for education, he says that if you're talking about access it's not fair to give some people knowledge and not others | Government | Gives some insight into the habitus of the man in charge of the revision |
| GW10 | In other words you should have a very fact based curriculum because that gives people the root out of their socioeconomic position in society | Government | Represents a particular view of education as well as creating the vision of linking academics to economic outcomes |
| GW11 | And I don't know<br><br>On the other hand, if you're turning off a whole load of people to science because it's very fact based and it doesn't connect with their lives then that's also an issue | Educationalists | |
| GW12 | They were happy for the three professional bodies, The Royal Society of Chemistry, the Institute of Physics, and the then Society of Biology which is now the Royal Society of Biology, to take a lead | Learned Societies | "They" refers to the Conservatives |
| GW13 | There was a policy group called Science Communities Representing Education (SCORE) which consisted of those professional bodies plus the Association for Science Education and the Science Counsel | Learned Societies | This group no longer exists |
| GW14 | They used to meet and it became a group of representatives from those organizations that did have a direct influence on policy | Learned Societies | Reveals an attempt to consolidate capital and influence the process of policy development |
| GW15 | So civil servants would to talk to SCORE if they wanted to have a view on science education | Civil Service, Learned Societies | This model allowed for more shared capital between the Civil Service and Learned Societies |
| GW16 | Whether that was a good idea or not I don't know because it took the science education academics out of the loop and the quality of the discussion was reliant on the individuals who represented the IoP and the SoB and to some extent they weren't necessarily educationalists | Learned Societies, Education Academics | Participant has strong leanings towards Educationalists |
| GW17 | So it was sometimes good it was sometimes very poor indeed | | |
| GW18 | So when the new curriculum came up it seemed the obvious thing to say | Learned Societies | "New" refers to the 2010-2013 Revision |

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| | (was) that the 3 bodies will develop the physics, chemistry, and biology curricula and try and consult on things that they share | | Shows a collaborative approach to developing curriculum |
| GW19 | It was very clear that the physical scientists and the biologists disagreed immediately about the content in terms of the additional content about applications and implications | Learned Societies | Reveals how the different Learned Societies had different views on the curriculum |
| GW20 | The physicists saw that as diluting the curriculum and the biologists were keen to keep the ethics | Learned Societies | Different foci for different scientists |
| GW21 | In fact the word ethics is still there once I think in the key stage 4 curriculum, and the chemistry lot was somewhere in between | | |
| GW22 | The individuals who (were) appointed by the professional bodies to do this curriculum development were people who had time to do so they weren't employed by those professional bodies and again they weren't the right people in my view to do that, it should have been a more consultative process | Learned Societies, Educational Academics | Reveals a tension between the two groups. Participant infers the Learned Societies were represented by individuals who understand science but not necessarily science education. Also underlines a less consultative process than other participants |
| GW23 | So the physicist was Paul Black who was very imminent scientist<br><br>Yes Paul Black from Assessment for Learning | Drafters | Physics drafter |
| GW24 | He's a great guy but he just did it all on his own, he wrote the physics curriculum and that's not the way to do it | Drafters | Paul Black has a long history with educational research/academia. The participant has issues here with his lack of consulting with the group |
| GW25 | The chemist was also not thought of as the right person | Drafters | Colin Osborne and Anthony Ashmore were the chemistry drafters |
| GW26 | The biology person was the author of text books so she had been a teacher but she isn't an education academic | Drafters | Anne Fullick was the biology drafter<br><br>Shows a distinction with educational academics and educationalists in general |
| | And she's written good text books but they're very traditional and she took this on and has the time to do it but again you could argue she wasn't the right person | Drafters | Once again discourages non academics in curriculum writing |
| GW27 | She didn't' have a deep understanding of curriculum development and the people who did probably weren't available to do that work | Drafters | Notes a distinction between science education and curriculum development |

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| | | | Also understands that the nature of curriculum development is tied to who is available to contribute |
| GW28 | We used to meet at the Royal Society of Biology and there was a representative from partner organizations who had an education people | Ed. Organizations | Different groups had direct interactions with each other |
| GW29 | These people sent their representatives their representatives to be part of this so called "dialogue" about how the curriculum should be | Ed. Organizations | Uses the phrase "so called" inferring many of the decisions were made outside the collaboration possibly giving loads of capital to the Drafters |
| GW30 | Again, they were people who were working in outreach for their subject area, they weren't specialists in curriculum development and they didn't have that experience | Ed. Organizations | Reveals a distinction between education academia and science outreach<br><br>Can you get a job in science outreach without having a background in science? |
| GW31 | They also didn't know about educational research and what research tells us about the order you should teach things in, the way you can build up a curriculum, etc | Ed. Organizations | Once again, a lack of familiarity with educational academia is seen as a weakness |
| GW32 | So it was quite a.....<br><br>It wasn't a terribly coherent discussion I would say | | |
| GW33 | But people were asked to express their views and these leads went away and wrote what they'd thought we'd said and we argued a bit more about it | Drafters | Exhbits the great amount of power the drafters wielded |
| GW34 | But then it went to the Dept. of Education and it came back as it is now so a lot of what we talked about wasn't really acknowledged | Civil Service | Infers a tendency for the Civil Service to accept what the Drafters interpreted from the meetings |
| GW35 | Yes, so it had to be much more factual than we were hoping<br><br>You couldn't have, for example, learning outcomes that were around ethical arguments that applied to a lot of different issues in biology | | |
| GW36 | It's almost the philosophy of science really and the nature of science but that's really been cut back so you're really down to the learning outcomes that are around curriculum topics | Government, Civil Service | This is the curriculum favored by the Conservative Government |
| GW37 | So that's what the process is, it goes to civil servants who then act on what they're told by the MP's in terms of what the policy is | Government, Civil Service | Cements them as in the Primary position |

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| GW38 | So the policy comes ahead of being informed by either research or experts in the field talking | All players | Truly a "top down" approach |
| GW39 | It may be peculiar as I don't know if it's the same in America but the civil servants change jobs fairly regularly so they are sent to the dept for education and then, after maybe 3 or 4 years, they may be sent to a completely different dept<br><br>So again they're not specialists in education | Civil Service | Another mention of how these individuals don't necessarily have the background to lead on curriculum policies |
| GW40 | They tend to then commission the odd expert, they choose people who have the kind of political agreement with their policies as their experts so to reinforce<br><br>They will only ask people who reinforce what they're thinking anyway but it's quite difficult to push against that | Government, Civil Service | Another example of Policy informing research instead of vice versa |
| GW41 | There's an increasing cynicism about educational research and its role | Educational Academia | Could infer a sense that the participant feels the role of the educational academic in policymaking is diminishing |
| GW42 | The mp's, for example, and current government they learned long division when they were 8 and they think every 8 year old should learn long division | Government | Too experienced in education but too inexperienced in education policy |
| GW43 | And they have limited experience but they have a view on education that isn't terribly well informed and the policies sometimes doesn't really chime with what educational research tells you | Government | |

Appendix G: Identifying Motivation Coding Scheme Ginny W

| What did they say? (Utterance) | Agents | Constructs of Tastes | Notes |
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| And more recently I was involved, when I was working at the Nuffield Foundation, I was involved in the Royal Society of Biology and, in their working party looking at the looking at the content of the new curriculum | Learned Societies (Biology), Ed. Organizations (Nuffield Foundation) | | |
| Now the trouble is, when you're trying to develop a new curriculum, particularly in biology I think, there are a lot of professional bodies associated with every area of biology mycology, parasitology, ect. that think their content should be included in the school curriculum | Academic Scientists, Industry Scientists | Learned societies show preferences toward filling the curriculum with their own disciplines | Not surprising. To a hammer everything is a nail… |
| And it's very difficult to get anybody who's capable of leading on the decisions that need to be made around what should and what should not be in the curriculum but I think there was a pretty big consensus that we needed to update the content around genetics | Academic Scientists, Industry Scientists | Distinct desire towards updating rather than conserving genetics in the curriculum | |
| I think people are strongly tied to what they learned at school and therefore what they think everybody should know and I don't think there's enough long term ongoing debate between educationalists and scientists about what are the building blocks of the knowledge you need to work in that area | Education Academics, Teachers, Academic Scientists, Industry Scientists | Preference towards what previous generations learned vs what current generations need to know | Susan B mentions a similar dynamic regarding a conversation with an "experienced" Minister about the teaching of HIV |
| So we did get some changes and we were very strongly in touch with the Wellcome Trust who at the time was working on a big educational program for genomics in schools | Wellcome Trust, NOWGEN | | |
| He was very articulate and managed to sort of convince people. It was kind of depressing that it hinges on individuals being able to argue the case rather than there being a proper process of what should be in the curriculum and how that decision is made | Wellcome Trust, NOWGEN | | |

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| In the end there were some small changes, some allusions to genomics right down into the GCSE but you have to think "well what do teachers understand by this" and there wasn't any sort of program of professional development associated with this change | Teachers | | |
| So whenever there's a change in the curriculum there's a lot of employers involved in having a chat about what is needed but in the end but our education system is driven by university entrance requirements and that is A-Levels and A-levels are designed according to what is needed by the universities for their undergraduate courses | Industry scientist, Universities | Universities are motivated by what is needed to prepare students for entrance? | |
| There's a tension there you could say<br><br>I've heard Michael Gove, the previous secretary of state for education, he says that if you're talking about access it's not fair to give some people knowledge and not others | Government | Perhaps motivated by providing the same knowledge to everyone? | |
| In other words you should have a very fact based curriculum because that gives people the root out of their socioeconomic position in society | Government | Could lead to more opportunity for social mobility | I would say this is more of a political argument than an economic or curriculum one |
| And I don't know<br><br>On the other hand, if you're turning off a whole load of people to science because it's very fact based and it doesn't connect with their lives then that's also an issue | Educationalists | Developing the next generation of great scientists | |
| They were happy for the three professional bodies, The Royal Society of Chemistry, the Institute of Physics, and the then Society of Biology which is now the Royal Society of Biology, to take a lead | Learned Societies | | |
| There was a policy group called Science Communities Representing Education (SCORE) which consisted of those professional bodies plus the Association for Science Education and the Science Counsel | Learned Societies | | |
| They used to meet and it became a group of representatives from | Learned Societies | | |

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| those organizations that did have a direct influence on policy | | | |
| So civil servants would to talk to SCORE if they wanted to have a view on science education | Civil Service, Learned Societies | | |
| Whether that was a good idea or not I don't know because it took the science education academics out of the loop and the quality of the discussion was reliant on the individuals who represented the IoP and the SoB and to some extent they weren't necessarily educationalists | Learned Societies, Education Academics | Tension between Educationists motivations and Learned Societies | |
| So it was sometimes good it was sometimes very poor indeed | | | |
| So when the new curriculum came up it seemed the obvious thing to say (was) that the 3 bodies will develop the physics, chemistry, and biology curricula and try and consult on things that they share | Learned Societies | | |
| It was very clear that the physical scientists and the biologists disagreed immediately about the content in terms of the additional content about applications and implications | Learned Societies | Application of learned material<br><br>Ethics of science | |
| The physicists saw that as diluting the curriculum and the biologists were keen to keep the ethics | Learned Societies | IoP-Content and knowledge<br><br>RSB-Context and application | |
| In fact the word ethics is still there once I think in the key stage 4 curriculum, and the chemistry lot was somewhere in between | | | |
| The individuals who (were) appointed by the professional bodies to do this curriculum development were people who had time to do so they weren't employed by those professional bodies and again they weren't the right people in my view to do that, it should have been a more consultative process | Learned Societies, Educational Academics | Different bodies consulting often results in different motivations | |
| So the physicist was Paul Black who was very preeminent scientist<br><br>Yes Paul Black from Assessment for Learning | Drafters | | |
| He's a great guy but he just did it all on his own, he wrote the physics curriculum and that's not the way to do it | Drafters | Motivated by a less than collaborative process | |
| The chemist was also not thought of as the right person | Drafters | | |

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| The biology person was the author of textbooks so she had been a teacher but she isn't an education academic | Drafters | | Participant shows a preference for academia |
| And she's written good text books but they're very traditional and she took this on and has the time to do it but again you could argue she wasn't the right person | Drafters | Tendency towards conserving the curriculum as opposed to expanding it | This is echoed by Oliver W |
| She didn't' have a deep understanding of curriculum development and the people who did probably weren't available to do that work | Drafters | | |
| We used to meet at the Royal Society of Biology and there was a representative from partner organizations who had an education people | Ed. Organizations | | |
| These people sent their representatives their representatives to be part of this so called "dialogue" about how the curriculum should be | Ed. Organizations | | |
| Again, they were people who were working in outreach for their subject area, they weren't specialists in curriculum development and they didn't have that experience | Ed. Organizations | | |
| They also didn't know about educational research and what research tells us about the order you should teach things in, the way you can build up a curriculum, etc | Ed. Organizations | Lack of motivation by educational concepts such as scope and sequencing | Makes you wonder how the initial questioning:<br><br>What do kids need to know? vs. What should be taught in schools? |
| So it was quite a.....<br><br>It wasn't a terribly coherent discussion I would say | | | |
| But people were asked to express their views and these leads went away and wrote what they'd thought we'd said and we argued a bit more about it | Drafters | | |
| But then it went to the Dept. of Education and it came back as it is now so a lot of what we talked about wasn't really acknowledged | Civil Service | | |

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| Yes, so it had to be much more factual than we were hoping<br><br>You couldn't have, for example, learning outcomes that were around ethical arguments that applied to a lot of different issues in biology | | | Changes in government lead to changes in priority |
| It's almost the philosophy of science really and the nature of science but that's really been cut back so you're really down to the learning outcomes that are around curriculum topics | Government, Civil Service | Knowledge-strong curriculum | Echoed by Dean T |
| So that's what the process is, it goes to civil servants who then act on what they're told by the MP's in terms of what the policy is | Government, Civil Service | CS motivated by government philosophies | |
| So the policy comes ahead of being informed by either research or experts in the field talking | All players | | |
| It may be peculiar as I don't know if it's the same in America but the civil servants change jobs fairly regularly so they are sent to the dept for education and then, after maybe 3 or 4 years, they may be sent to a completely different dept<br><br>So again they're not specialists in education | Civil Service | | |
| They tend to then commission the odd expert, they choose people who have the kind of political agreement with their policies as their experts so to reinforce<br><br>They will only ask people who reinforce what they're thinking anyway but it's quite difficult to push against that | Government, Civil Service | | |
| There's an increasing cynicism about educational research and its role | Educational Academia | | |
| The MP's, for example, and current government they learned long division when they were 8 and they think every 8 year old should learn long division | Government | Motivated by what previous generations have learned | |
| And they have limited experience but they have a view on education that isn't terribly well informed and the policies sometimes doesn't really chime with what educational research tells you | Government | Motivated by their own previous experience | |