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# Teachers, Learners and Edu-Business Co-Constructing Mathematics Curriculum Implementation: An Insider's Lens in Cross-Phase Longitudinal Research

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**Abstract:** This paper draws on a five-component, large-scale, longitudinal and cross-phase mathematics curriculum implementation study in England from the vantage point of an insider to overlapping school, policy and edu-business actor communities. It probed those actors' emergent co-interpretation of, and response to, a new mathematics curriculum in England, analysing the ways in which edu-businesses, teachers and learners mediate mathematics curriculum policy documents through their own interpretations and schema. The combination of common 'classroom-close' research tools supported synergies of cross-phase and longitudinal lenses. The paper contributes an enhanced conceptualisation of inter-actor influence, a theorisation of learner as policy actor, and an understanding of constraints on mathematics policy-driven change at teacher and learner levels, including challenges to communication of intended curriculum policy, across phases of schooling. The approach appears fruitful for analysis of the experience and mediation of mathematics curriculum policy by key policy actors.

**Keywords:** mathematics curriculum; policy actor; edu-business; institutional ethnography; cross-phase; classroom-close research



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## 1. Introduction

The study of education policy implementation has been of considerable interest in recent years, with a variety of theoretical and methodological approaches adopted. Policy communication takes shape via a nested range of levels, texts and actors, with 'iterative refraction' [1] of key messages at successive stages of communication. Here, I focus on (mathematics) curriculum policy, which is assumed to have the potential both directly and indirectly to shape learning outcomes. At each layer of communication from curriculum writer to learner in the classroom, there are complexities of relationships and meaning-making shaped by different curriculum actors [2,3]. As those meanings take shape, there is interaction between different actors, often mediated by curriculum-interpreting artefacts [4–6]. This paper focuses on evidence from the study of such phenomena, using approaches we frame as 'classroom-close'. The context is one where significant curriculum interpretation roles were also played by one 'edu-business', conceptualised as private for-profit and not-for-profit businesses with power and agency in the field of education [7]. Throughout the paper, we understand the school mathematics 'curriculum' to exist in at least three forms—the intended curriculum as captured in authoritative written documentation, implemented curriculum at successive levels of communication, and learner-attained curriculum—as adopted by Mullis et al. [8].

The curriculum policy literature addresses high-level inter-institutional or intra-school management policy enactments (e.g., [2,9] respectively). There are widespread small-scale classroom-focused policy implementation studies, but related large-scale studies usually stop short of a classroom or learner focus. However, the study of larger-scale, cross-phase curriculum policy enactment, at an individual teacher or student level—arguably the key intended objects of curriculum policy if that is to meet its goals—is under-represented in

the literature. This paper analyses, and argues for the validity and contribution of, the approaches we adopted in a five-component cross-phase, longitudinal implementation study as quantified in below. The context was the implementation of revised mathematics curricula for learners aged 5 to 18 rolled out in England from 2014, with first assessments in 2017 for learners aged 16, and in 2019 for learners then studying calculus-rich mathematics pathways pre-university. At all levels, there was an enhanced focus on mathematical reasoning, problem-solving and communication.

English school education is typically organised as primary (years 1–6, ages 5 to 11) and secondary (ages 11 to 18, or 11 to 16 plus 16–18, in institutions here generically named 'schools'). In-school 'mathematics leads (MLs)' are key school-level influencers. Associated with the official codification of intended curricula (the written 'National Curriculum' and A-Level 'specification') were a host of other artefacts reflecting curriculum interpretation. These include curriculum resources and those relating to assessments at ages 11, 16 ('GCSE Mathematics', offered in two overlapping 'tiers') and 18 ('A-Level Mathematics'), both entirely assessed by written timed papers. It is worth noting that OECD [10] characterises both GCSE and A-Level Mathematics as unusually demanding for the relevant cohorts. The wider context over recent years is one of marketised assessments at ages 16 and 18 that are 'high-stakes'—for learners, teachers and schools—and assessments at age 11 that are nationally produced and relatively high-stakes (for schools and teachers, but not learners). Assessments at 16 and 18 in England operate within a regulated but competitive marketplace; teacher and learner texts and other classroom-related materials are also marketised, but not regulated.

The focus-revised mathematics curricula are intended to support mathematics learning and progression via a renewed focus on deep conceptual fluency, on mathematical problem-solving and reasoning, and on rigorous communication of those processes. It is known that teaching for such aspirations is challenging (e.g., [11]). Associated policy discourses in England have privileged economic good—for individual and society—and employed discourses of equity of opportunity and international economic competitiveness. Such discourses underline the centrality of mathematics education in much education policy work across the globe. Education policy in England involves a wide range of policy actors, including teachers and a variety of edu-businesses, as analysed by Ball and Junemann [12]. Such policy roles exist in all education systems, but placements and profiles relative to central structures vary. Actor roles and interactions, and the use of power, in mathematics education networks remain oblique; this paper contributes to filling that gap.

Below, we discuss theoretical and methodological aspects of the study, and the revealed affordances of those. We draw on learner as well as teacher accounts and perspectives. Through much of the study, edu-business perspectives are largely inferred from those communicated in their curriculum and assessment materials; we show that these both directly and indirectly impact what mathematics is made available in the classroom. We also report edu-business responses to emerging research findings. We demonstrate that the adopted approaches can expose the policy roles played by learners aged 5 to 18, the relationships between learner and teacher perspectives, and the interplay of both with curriculum as interpreted by 'third-space' actors such as edu-businesses. Importantly, this study is able to illuminate how such phenomena might compare across phases of schooling. These approaches also contribute to the development of a theorisation of learner as policy actor. They also support additional evidence of the communication and validity challenges associated with mathematics education policy-driven change.

The underlying study was funded by one edu-business, nationally influential as the market leader in both mathematics curriculum materials and mathematics assessments (and related resources) at GCSE and A-Level. The edu-business also provides teacher development and is proactive in policy engagement. The funder's stated purpose, developed in conjunction with the national DfE and assessment bodies, was twofold. First, they targeted evidenced development of their curriculum and assessment materials for mathematics learners aged 5 to 18 so as to better support curriculum intentions for learning,

by identifying resource- and curriculum-specific issues as teachers and learners came to work with new curriculum expectations. Second, they sought a better grasp of curriculum reform processes, from policy statement to classroom implementation to learner learning, for both business and wider benefit. Initially, the five components of the study, together spanning mathematics education from 5 to 18, were undertaken and reported separately in, e.g., [13–16]. In then taking an overview in, for example, [17], we have started to interrogate the synergies of the five components. In this paper, we set out the overall study context and indicate the nature of some of the findings from cross-phase analysis; elsewhere, we begin to theorise some of the interactions in more detail [18].

Throughout, the author was employed to lead a team of external-to-funder subject phase-expert researchers and was responsible for all aspects of the research, including the framing of research questions from the broad goals communicated. For each component, we asked, '*How is the intended mathematics curriculum being enacted and experienced in the classroom, with what funder curriculum and assessment resources, and why? What is the impact on teacher and learner learning?*' This paper focuses on some of the answers to related questions the research team then asked when considering the study as a whole, catalysed by emerging data:

> *How do teachers, learners, and one edu-business (the funder) co-construct curriculum implementation? (and how does that vary across school phase?)*
>
> *In what ways, if at all, can learners be conceptualised as policy actors?*

Importantly, because of the market leadership of the funder's products in England, findings have broad applicability across English mathematics education, while the potential of the approaches generalises to mathematics curriculum implementation studies in any context, and possibly to work in other parts of the school curriculum. However, in England as elsewhere, mathematics remains a key curriculum focus for individuals, schools and nationally, with associated both affordances and constraints [19].

The study contributes conceptualisations, contrasts and synergies of teachers' work with curriculum and assessment resources in relation to curriculum planning and realisation. It also illuminates a range of curriculum-agentic roles of learners, and the interplay of those with teacher and funder resources.

## 2. Theoretical Approaches

Ball et al. [2] conceptualise in-school policy-related interactions as often 'complexly configured, contextually mediated, and institutionally rendered', and that was certainly our experience, as illustrated below. However, we sought emergent commonalities, as well as variations, across different school contexts. We used two complementary theoretical approaches to conceptualise cross-phase policy implementation processes, analysed below. These framed research design, analysis and interpretation, and together contributed a range of insights.

### 2.1. Policy Actors

We worked with the [20] extended version of Ball et al.'s [21] policy actor typology (Table 1, below, exemplified for this context). Such typologies support a shift away from conceptualisations of the teacher as a passive implementer of policy [22]. Related policy networks are complex, but our focus was on the edu-business and teacher, as well as potentially learner, as policy actors, with edu-business approaches mediated through their curriculum and assessment materials. All participants were working with those: the funder in their production, teachers usually employing those in their lesson planning and often also directly in their teaching, and learners in a variety of ways, usually including direct interaction with a subset of the curriculum materials. The funder had already interpreted the intended curriculum in important ways and so, at the classroom implementation stage, functioned as a curriculum 'narrator'—but also, in an ethnographic sense, as a curriculum-maker. Similarly, classroom teachers in their approaches to curriculum texts, and the

relation of those to curriculum planning and enactment, were also policy actors. They might potentially be active 'curriculum-makers' who are policy 'narrators' or 'enthusiasts', or might instead harness the received curriculum according to context: predominantly 'translators', or a variety of constructive 'critics' [20]; others might function as curriculum 'survivors' or 'receivers'.

**Table 1.** Policy actor typology, exemplified in this context (adapted from [2] p. 49); * extended in [20].

| Policy Actors | Policy Work |
|---|---|
| Narrators | Interpretation, selection and enforcement of meanings, e.g., edu-business interpreting curriculum priorities to communicate those in teacher guides. |
| Entrepreneurs | Advocacy, creativity and integration, e.g., MLs suggesting ways in which curriculum materials can be adapted to build on a teacher's particular pedagogical strengths. |
| Outsiders | Entrepreneurship, partnership and monitoring, e.g., school governors interrogating classroom curriculum work in relation to attainment. |
| Transactors | Accounting, reporting, monitoring/supporting, facilitating, e.g., Headteachers critiquing impact of curriculum resources. |
| Enthusiasts | Investment, creativity, satisfaction and career, e.g., class teacher making substantial and sustained investment in getting to know curriculum resources. |
| Translators | Production of texts, artefacts and events, e.g., ML selecting from resources to craft a 'scheme of work', or class teachers planning the incorporation of published materials into their lessons. |
| Critics | Union representatives: monitoring of management, maintaining counter-talk OR * engaging in positive critique, enhancing enactment for the context, e.g., teacher analysing aspects of resources that do not work well for some learners, and re-crafting those. |
| Receivers | Coping, defending and dependency (may be inexperienced), e.g., time-pressed classroom teacher struggling to keep track of rapidly changing new assessments. |
| Survivors | * (May be experienced, weary). Dampening local policy aspirations, e.g., change-weary teacher looking to make minimal use of new materials while apparently conforming to school expectations. |

In these 'policy actor' terms, it is tempting to identify learners as 'receivers' of curriculum, often coping and depending—on texts, including teacher narratives—and subject to popular hegemonies of the school mathematics experience as an imposed, and received, pathway to high-stakes assessment. But in the context of our emerging data, we moved to perceiving learners also as potentially 'survivors', or active 'translators', making new meanings underpinning their own sense of curriculum as experienced, or as a variety of constructive 'critics' or even 'enthusiasts'. Adopted curriculum roles can change over time, especially as teachers come to engage with a new curriculum; learners, potentially active policy actors as they engage with curriculum meaning-making with appropriation of authority and agency, may also change their adopted roles as they mature in their relationship with the curriculum and with their teachers.

There is, though, a challenge in accessing patterns of relationships between texts, the social dimensions of policy as practice, and institutional relationships and discourses, as well as their development and evolution: the study findings, consistent with much of the implementation literature, suggested that the associated roles and processes were highly contextualised and socialised, often at least partly bottom-up and emergent. They were frequently also apparently non-deterministic, reflecting the fundamental complexity of classroom work.

Working within our qualitative, exploratory and longitudinal approach, we found that further methodological conceptions were needed to address participants' apparently

idiosyncratic perceptions of the curriculum meaning-making and agency available to them, particularly in relation to impact of the variety of texts available. For these purposes, we adopted some of the conceptual tools and ontologies of institutional ethnography [23], which seeks to explain how social action in one 'world' (here, school, department or classroom) can be understood with the lens of another—eventually, that of policymakers at national level, but at an intermediate level, that of researchers or edu-businesses such as publishers.

### 2.2. Institutional Ethnography

In an institutional ethnography paradigm, interview/focus group data, but also accounts of classroom observations and of texts, are conceptualised as subjectively co-constructed by researchers with participants through interactions with and in the field. They address actions, processes, meanings, goals and contexts of everyday worlds *from the standpoint of the participant* [23]. This seemed particularly suitable for our goal of understanding subjective (co-)construction of enacted curriculum. Such research requires immersion in the focus context, and researchers' backgrounds significantly impinge on such co-constructions, even though efforts were made to 'step outside' when interviewing, to validate use of common semi-structured data collection methods within each component of the study, and to ground interpretation in the data. In this case, the author/lead researcher was very much an 'insider' to the overlapping communities of mathematics education policy as it is implemented from formalised curriculum to edu-business interpretation to classroom enactment: she was a very experienced classroom teacher formerly contributing to curriculum material and assessment production for the funder edu-business, and is still involved in central policy work. We argue that this is a considerable advantage for institutional ethnography work.

The institutional ethnographic approach progressively informed design and data collection decisions, and eventually, analysis of power and influence relationships within and beyond schools, including via Smith's [23] approaches to texts in action. Institutional ethnography aims to build accounts of ruling relationships 'from below' and 'look out beyond the everyday to discover how it came to happen as it does' [24], probing connections between individuals and social structures even as participants contribute to those structures. Importantly, though, it is also committed to going beyond any one individual's experience.

Within institutional ethnography, we asked in particular, the following questions: Which are the (policy, curriculum, assessment or professional discourse) texts that carry authority and meaning to teachers or learners, in relation to the mathematics curriculum? How are they selected, and their discursive and interpretive natures understood, harnessed and appropriated by actors in the school mathematics policy system? We included here the edu-business curriculum and assessment materials that were the focus of the studies, but also sought curriculum-related texts from other sources, for example, department-level 'schemes of work', school-level 'learning priority' documents, or social-media-recommended websites that learners harnessed—together with the discourses evidenced. The approach sought to explore the ways in which teachers and learners used these different resources for a variety of curriculum-related purposes, their perceptions of the related choices and agency available to them, and how that changed over time. In particular, Smith's [23] notion of 'inter-textual hierarchy' was used to tease out from our data which texts were privileged, for what purposes and when, and the surrounding discourse. We conceptualised teacher or learner interaction with text as agentic and mutually developmental with text, as in [25].

I outline below the tools developed to work within these theoretical paradigms. I then indicate the range and scope of findings, and especially the contributions in relation to the ways in which teachers, learners and edu-business act to co-construct curriculum.

## 3. The Study: Methods

We used a combination of well-established methods as outlined below: curriculum-related document analysis (representing edu-business interpretation of curriculum where appropriate), semi-structured interviews with teachers, semi-structured whole-lesson observations, learner focus groups, and surveys completed by teachers and by learners. These were adjusted as considered necessary, and ethical, during the global pandemic of 2020–2022, with learner focus groups and lesson observations replaced by online surveys of post-primary learners in 2021 and part of 2022. Sample research tools are given in the Supplementary Materials. We conceptualise our approach as 'classroom-close': it has much in common with the 'close-to-practice' research theorised by Wyse et al. [26], but the research questions were determined by the funder and central policy actors, rather than by teacher practitioners, and the impact was designed to be focused on understanding and development of support, including policy support, for valid curriculum enactment, rather than directly on teacher practice. Data, though, were derived from full-lesson observations, from materials closely related to classroom teaching and learning and its assessment, and from teacher and learner reflections on both those. Data were synthesised and applied in a novel way and at a novel scale for this field, supporting synergies of both cross-phase and longitudinal implementation research.

Research tools were edited iteratively, and for phase- and age-appropriateness, within a broadly common design for all five components of the study. The author led all fieldwork (by five phase-knowledgeable subject-expert researchers external to the funder), and also designed and piloted all aspects of the study. Data collection sampled year groups from all phases of English school education and is summarised in Table 2 below. Analysis supported the identification of similarities and differences within and across schools, as well as across phases. The reported five components A–E were longitudinal, each over at least two years of early curriculum implementation; researchers interacted with participants in each school at least termly, including, except during the pandemic, via full-day classroom-close visits each Spring term that included full lesson observations of participating classes. The study serves to evidence developing teacher and learner perceptions of the experienced curriculum, individual, social and institutional agency, authority, roles and responsibilities, and the meanings received from a range of curriculum-related texts.

Four funder-internal efficacy researchers supported the study administratively and carried out some (validated) analysis and writing. This 'internal–external' (to funder) researcher partnership supported access to detailed knowledge of resource and assessment material development, structure and content, as well as to additional documentation not in the public domain, although it also brought ethical tensions that are addressed below. Funder product teams were involved at least annually to consider and inform proposed research tools and emergent findings. We also engaged national Department for Education, inspector and Ofqual (national office for qualifications) personnel via summaries of annual findings, and they each contributed to further development of tools to ensure aspects of implementation of particular interest to them were probed. The study approach therefore offered symbiosis of a range of policy actor roles inside/outside policy-active institutions, bringing concomitant threats as well as advantages [27]. In particular, the inter-actor influences discussed below were also impinged on by relationships with the researchers. The main tool for addressing related tensions was a conscious and frequent application of reflexivity, in parallel with the above actions. However, the author's 'insider' roles also offered an existing community immersion that particularly supported institutional ethnographic lenses.

We sought a contextualised and embedded understanding of how the new curriculum was being realised and the critical influences on that. Standardised or national assessment quantitative learner progression data were used to locate the sample within national attainment and progression patterns, and identify any demographic or prior attainment links with apparent constraints on, or choice of, curriculum enactment. All interviews, observations and focus group conversations were semi-structured in order to optimise

balance between validity of response or observation to support grounded analysis and relevance to research foci. Our approach offers an opportunity to develop a grounded, rich understanding of edu-business, teacher and learner practice and perspectives, together with their inter-relationships, and to connect theory with both policy and practice.

**Table 2.** Study timing, participants, and data collection (*: pandemic-constrained).

| Study Component | Year Group/Age | Schools (2 Classes Each) | Focus Group Students | Teacher Interview Transcripts | Pre-/Post-Study Class Progression Data | Lesson Observation Notes | Useable End-of-Year Student Surveys | End-of-Year Teacher Surveys |
|---|---|---|---|---|---|---|---|---|
| A: Primary Cohort 1 (2016–18) | Y1–2 (Age 5–7) | 9 | 70 | 68 | 17 | 18 | - | - |
| A: Primary Cohort 2 (2016–18) | Y5–6 (Age 9–11) | 9 | 72 | 68 | 18 | 18 | - | - |
| B: Primary Cohort 3 (2019–21) * | Y1–2,3–4 (5–7,7–9) | 24 | 216 | 96 | 54 | 54 | - | 96 |
| B: Primary Cohort 4 (2019–21) * | Y5–6 | 21 | 168 | 84 | 42 | 42 | - | 84 |
| B: Primary Cohort 5 (2021–22) * | Y2,4,6 | 9 | 86 | 19 | - | 18 | - | 18 |
| C: Secondary Cohort 1 (2016–18) | Y7–9 (Age 11–14) | 29 | 138 | 136 | 28 | 44 | 785 | - |
| C: Secondary Cohort 2 (2016–18) | Y10–11 (Age 14–16) | 31 | 164 | 144 | 34 | 48 | 845 | - |
| D: Secondary Cohort 3 (2016–18) | Y11–12 (Age 15–17) | 20 | 193 | 60 | 25 | - | 795 | - |
| D: Secondary Cohort 4 (2017–19) | Y11–12 (Age 15–17) | 21 | 192 | 61 | 23 | - | 807 | - |
| E: A-level Cohort 1 (2017–19) | Y12–13 (Age 16–18) | 11 | 156 | 50 | 50 | 22 | 432 | 50 |
| E: A-level Cohort 2 (2018–20) * | Y12–13 (Age 16–18) | 12 | 144 | 54 | 54 | 24 | 420 | 51 |
| E: A-Level cohort 3 (2019–21) * | Y12–13 (Age 16–18) | 12 | 71 | - | 22 | 14 | 640 | 65 |
| E: A-level cohort 4 (2020–21) * | Y12 (Age 16–17) | 12 | - | - | 13 | | 394 | 43 |
| Total | | 220 | 1670 | 840 | 380 | 302 | 5118 | 407 |

The samples recruited were stratified by several school characteristics known to impact teaching and learning, in proportion to their occurrence nationally: catchment area type (city, urban, urban fringe, rural), inspection assessment grade, level of historic learner performance, socio-economic and demographic composition of learners, and governance type. However, participants opted in, so were necessarily confident to welcome researchers into their lessons and sufficiently relaxed to devote time to research processes: they are therefore unlikely to be the most stressed in the system. This appeared not to fundamentally affect the measured representativeness of the sample, except post-16, where the achieved sample was skewed towards slightly higher-attaining school/college mathematics cohorts.

Small-scale pilots for the first four components listed were used to calibrate age-appropriate approaches to informed consent and to research tools. For other components, initial tools were piloted informally with a small group of learners and/or teachers comparable with those targeted. Overall, data collection was as in Table 2.

The main study for primary cohort 1, for example, followed classes of learners through years 1 and 2 and featured termly audio-recorded and transcribed teacher interviews, the second of which each year drew on the lesson observation made. As far as possible, the study followed a whole class and its mathematics teachers over at least two years. Class teachers and school maths leads were interviewed annually in the Autumn with a focus on individual, contextual and high-level implementation data collection. The requested focus for the Spring whole-lesson observation was a renewed focus of the new curriculum, such as the development of mathematical problem-solving or reasoning. This was potentially a 'telling' such opportunity [28], namely one which, while remaining deeply context-dependent, might most clearly expose to observation curriculum implementation challenges and opportunities. Teacher interviews probed the range of the research questions. These were revisited in successive interviews so as to discern development of approaches and attitudes over time, as participants adjusted to the new curriculum.

We used semi-structured tools, including observation schedules, iteratively developed through the study. Post-observation, four–six learners of mixed gender and mixed prior attainment, drawn from the class observed, took part in a focus group, also audio-recorded and transcribed, that probed the typicality of the lesson observed, the use of resources and teaching/learning activities seen, and other aspects of the received curriculum and their preferred approaches to learning. We also interviewed the class teacher, seeking reflection on key aspects of enactment.

Towards the end of each year, we either interviewed teachers again (where context supported that) or used an online survey to solicit their perspective on emerging implementation and resource/assessment use. We also surveyed all older classes at that stage. Kelley et al. [29] suggest that surveys, particularly online and of participants not well known to the researcher, can result in superficial responses, so we were cautious in their use. Quality of learner responses did indeed vary, with a ~2% wastage rate; however, many were mature, reflective and detailed. Where we used surveys for teachers, because of individual, school or wider constraints, we had already built professional relationships with them, and the typical depth and focus of response was judged high, although obviously lacking opportunity to probe. Additionally, online surveys respected the respondent by allowing choice in timing of completion. Integral response spreadsheets minimised the data handling required before analysis, with processing starting only at the cleaning of data stage: this approach was increasingly adopted through study components, as we gained confidence in the achieved quality of data, and as pandemic pressures shifted the practical and ethical balance of decisions.

Table 2 shows that similar approaches were used in all components, except for Secondary cohorts 3 and 4. For them, the focus was on learner- and teacher-reported experiences of, and approaches to, preparation for GCSE examinations at age 16, followed the next year by exploration of the post hoc reflections of learners on their GCSE experiences, together with their, and their teachers', emerging perceptions of the appropriateness of their mathematical preparation for the post-16 pathways on which they had by then embarked. The overall scale of the data collected from teachers and learners is as shown in the last line of Table 2.

### 3.1. Research Integrity

Any study of the efficacy of funder-published materials, with funder employees also contributing analysis, is susceptible to ethical issues relating to conflicts of interest, to criticality and to independence of findings, while also offering the advantages indicated above. Analysis and interpretation were achieved through discussion and validation by the range of ten researchers involved, and sometimes, participants too. Ethical approval was obtained from the author's university prior to all study components (RECs 836, 837, 855, 1019, 1108). All participants were repeatedly assured of a wish for direct and constructive critique of the focus funder curriculum, as well as curriculum and assessment resources, and the study has already resulted in significant developments being made to those. It has also supported the development of national assessment scrutiny and guidance. Throughout the studies, there were inevitably ethical judgments to be made—about how far to press teachers not responding to emails, when and how to communicate with schools once we were in lockdown, how to present the variety of teaching, and of the effectiveness of related learning, without judgement of teachers, etc. These have been addressed via reflexivity on the parts of the funder-internal and external leads.

Details of the study approach and, post-analysis, emergent findings were given external scrutiny by academic colleagues in local and national fora, by funder personnel including international senior staff, and by those in national policy fora and Ofqual/DfE teams considering reported outcomes.

Additional actions taken by the lead researcher to support research integrity included assumption of editing control of all surveys, synchronous data access with funder personnel, shadowing with the funder-internal lead of a stratified sample of fieldwork events

for consistency of approach and interpretation, validation of a random sample of transcriptions with recordings, and cross-validation of stratified samples of coding and of emergent sub-themes. High-level field researcher perceptions of implementation were triangulated against data and interpretation, with mismatches occasioning a revisit to the relevant data, or occasionally to one or more participants, for resolution. Similarly, all draft writing was validated by the lead researcher via stratified sampling of the range of data. Assessment data used to monitor the attainment and progression of participating learners, within national profiles, was via age-specific commercial tests standardised nationally, or (where available) national test outcomes at ages 7, 11, 16, 17 and 18: the slight inconsistency inherent in this approach was adopted in order to balance robustness of research outcomes against impact on participants. All interactions with learners due to take national examinations were completed the previous term, for similar reasons. In all reporting, care was taken to ensure typicality of the evidence cited, except where otherwise indicated.

Such research is not without further ethical tensions, for example, between the degree of contact necessary to establish trust and openness, and the disruption research participation can cause to school routines and core work. The intentions of edu-business in funding such research are assumed to be beneficent, on balance—though such research is also likely to increase their market share, and could also be argued to support a high-stakes marketised assessment regime that many would question. We in fact heard little overt criticism of the immense power of edu-business within that regime, but teachers and learners have de facto to work within that context. Although we took care to be as inclusive as possible of learners in our participant schools, we also note that the design of this study marginalises the standpoints of some teachers and learners: all participants were engaging in some way with written curriculum texts, largely from a single, if pervasive, publisher source, so were, for example, unlikely to be the most divergent of curriculum 'narrators'. Similarly, teachers opted in to the studies and with Headteacher consent, so were probably not among those most oppressed by the performative nature of much of England's education system. However, we reiterate that the achieved sample was, as above, broadly representative of the school population except in Study E, though at the school and student level that was largely representative of the (relatively high-attaining) A-Level Mathematics population.

### *3.2. Approach to Analysis and Interpretation*

For the overall study, as reported elsewhere (for example, [30]), we adopted reflexive thematic analysis of the qualitative data [31], to which we then, for this paper, applied the above theoretical lenses so as to make contingent meaning. Consistent with Smith's [23] approach, our analysis for was initially thematic within research questions (here, interactions between any two of edu-business materials, teacher, and learner, and evidence of a learner interacting with policy, directly or indirectly). It also used elements of a constructivist grounded approach [32] to identify common sub-themes, while searching for meaning initially at an individual level. NVivo was used as an analytic tool that supported deeply structured understanding of all qualitative data, with emergent grounded 'child nodes' that offered transparency of structure and of analytic allocation for validation. Such nodes were followed through for organisation of internal reports to the funder. Given our theoretical and interpretative lenses, our analysis focused on depth and range of understanding, rather than a quantitative summary of essentially qualitative data, except for attainment progression data. This paper focuses on three of the emergent themes, as indicative of the potential for a cross-phase analysis: the learner as a policy actor or 'curriculum-maker', the interrelationships between teacher and learner responses to curriculum resources, and edu-business as a co-constructor with teachers and learners of the experienced curriculum. The first of course focuses on learners' perspectives, the second on both learners' and teachers', and the third on interactions of either with the funder edu-business, usually indirectly via their curriculum or assessment-related materials.

With a focus on texts, the study complements an existing international body of research that conceptualises, monitors and interprets evidence of the practice and impact of teachers'

and learners' use of curriculum and assessment-related resources, e.g., [19], as one aspect of curriculum implementation. It does so in collaboration with an influential edu-business, enabling exploration of curriculum actor relationships with texts (understood as including school- and classroom-level discourse) and exposure of a variety of power relations shaping local individual teacher and learner experience. Here, the funder edu-business as policy actor exerted power via both curriculum and assessment materials and surrounding texts—communications to teachers and learners, assessment 'surround' materials, messages conveyed in teacher professional development, etc.—and so they acted as one 'narrator' of curriculum in Ball, McGuire and Braun's [2] terms.

Oates [33] highlights the desirability of 'curriculum coherence': deep alignment of all parts of a curriculum system, including the written intended curriculum, the enacted curriculum, resources, teacher capacity and teaching approaches, assessment, etc. He identifies a particular role for curriculum materials in communicating and interpretating central curriculum intentions, for both teachers and learners, and the findings below point to a similar role for assessment materials, with the funder edu-business playing a key role in both. One obvious consequence of any lapses in coherence is that users of texts have to assign inter-textual hierarchy: examples of this are outlined below, though we also argue that an edu-business developing both curriculum and assessment materials is in a relatively strong position to support curriculum coherence.

## 4. Indicative Findings

To illustrate the contribution of the methodological approach to a policy field, some of the areas in which a distinctive contribution has been supported are outlined below. In quotations, 'By6L1', for example, refers to Study B year 6 learner 1, 'DT3' to study D teacher 3, 'Cy8LO' to study C year 8 lesson observation, etc. Almost all quotations are from mid-year focus groups (or, for teachers, interviews), since those often offered the most direct communication of participant views; other sources are indicated as 'LO' as above, or as 'survey', or with documentary source. We address each of the selected emergent themes in turn, referring to cross-phase evidence patterns as appropriate: there were a variety of cross-phase commonalities and differences identified, together with variation within and across schools. At a high level, we show how the longitudinal approach exposed issues not only for the inception, but also for the sustainability, of curriculum system coherence. We evidence ways in which the habits, skills and dispositions of teachers *and* learners interacted with the focus curriculum and assessment materials over time, including as those materials changed. Together, these framed the emergent meaning-making and practice at classroom level.

### *4.1. The Learner as Curriculum Policy Actor and Curriculum-Maker*

School learners are commonly conceptualised, at least implicitly, as passive 'receivers' of curriculum, and our data supported that in some classrooms. However, the vast majority of our participant learners of all ages (at least 90%) appeared willing and constructive (though sometimes constructively critical) participants in their mathematics education. Learners very frequently made choices among the texts available to them at some point in the lesson observed. Even in primary classrooms, we almost always observed at least some learners choosing between, and selecting from, teacher or class discourse, front-of-class slides, textbook or practice book presentation, or peer learner, as their first external reference point for independent work. For almost all sample learners to around age 15, the dominant text, and source of mathematical authority, appeared to be teacher discourse rather than curriculum or assessment materials, though in at least 70% of focus groups across studies, learners identified particular features of written texts that spoke to, engaged and excited them:

> *I like how you can choose, . . .what method you want to do, and explain why. If someone (in the book) says something like this, and then someone says something like that, you can choose the easier method to work out the answer (By4L1);*

*Always after the challenge there tends to be a Reflect. I think they're very useful, because once you've done your work, sometimes I feel like I need a bit more thinking about it so I don't just forget about it (By4L2);*

*I really like the Challenges. They're quite fun. They're like, although sometimes it's hard to explain things, I actually like quite a bit of a challenge (By4L3);*

*The Reflect is the hardest one so that's why we do it together (By2L1); And sometimes the Challenge is really hard too (By2L2); Yes, because Challenges are meant to be very hard (By2L3).*

As learners approached GCSE examinations at age 16, though, and particularly in Spring of year 11, assessment texts and narratives came to dominate:

*A small question with a lot of marks, so it gives you a hint it's going to be a difficult question (DL1);*

*So now that, because I'm getting 50% on most of (the papers), and that's a 4, so I know that if at least I've done half of it, then I've got a 4, which that means that that extra for a 5 is kind of just that 10% more (EL1);*

*I find I just like to build my confidence. Because if I'm struggling with one of these (early questions), I'd be thinking, how am I going to pass if I'm struggling with the first few? (CL1).*

This was often abetted by teacher performativity [9] approaches, evidenced in both classroom observations and teacher interviews in both year 10 and year 11:

*We think that's the way to go to just start preparing them a bit more for common questions (DT1);*

*I'm trying to get them to get the first 10 questions, I'm trying to get them to get them just 100%, they make some stupid mistakes, it's unbelievable, so I'm just trying to get them to try not to rush it, I'm still trying to do that mark a minute thing (DT2).*

This led more reflective learners (at least half of focus group participants, across demographic groups) to adopt a 'curriculum narration' role, making active choices among a range of examination-focused resources—but also often adopting 'constructive critique' [20] of curriculum, resources and enactment:

*I think the exam pressure sometimes gets to a learner, so if you kind of have things in bold, it. . . I've done many questions where I think I'm answering the question, and I look back at the question, and I've answered something completely different. So I'd have to cross it out and restart. So I feel like bold would draw my attention better to what I need to do (DL2);*

*If you want the maths paper to be like strictly about maths and learn how to do it, then bolding it. . . But if you want it to be more about problem solving and like picking up what you want to do then obviously not (DL3);*

*There's 160 people in our year, and they're putting us all under the same lot of pressure to do one style of exam. . .And everybody has different learning styles and they want 160 people to sit the exact same exam and get the grade. . .if they're sitting us all in the same exam people will thrive off certain questions (EL2).*

There was, though, considerable resistance among mid-to-lower-attaining GCSE learners to some examination-linked experiences that were perceived as oppressive and 'miserable', particularly in retrospect:

*I put so much pressure on myself to pass and I was just stressing the whole time. I need to pass, I need to pass. It's just not a nice situation (DL4);*

*Years 10 and 11 were just miserable: there is so much to know, and I wasn't succeeding with the papers, it got more and more stressful so in the end I tried to avoid them (DL5);*

*Some of the worded questions in the exams don't always relate to experiences I've had. I can do the maths in lessons, but some of the exam questions seems designed to wrap that up so that I stress about what maths to use and then I can't show what I can do (DL6).*

A few made suggestions as to how to allow learners to show more of what they were capable of; one was to include course work *'maybe like having some coursework like added to the mark' (DL8)* or *'more multiple choice questions' (EL3).* About 50% of learners in affected cohorts could articulate advantages of engaging with authentic or familiar, realistic contexts, although a further about 25% were sceptical about such attempts:

*Like the fish tank with the sand in it and then you have to convert the volume into meters, I think that's quite a good question to have in there. Because that's sort of almost a real-life situation, not many of the questions are (CL2);*

*Some of the questions are just silly, and that winds me up: whoever heard of someone buying 150 watermelons? (CL3).*

A range of learners commented on the value to them of provided, or self-initiated, diagrams:

*I think the diagrams help because, for me, if there's not a diagram I always draw . . . a diagram, or . . . a graph or something, so that . . . I understand it more than just the words. . . It's hard to visualise in your head without a diagram (CL4);*

*I think maybe for certain questions more diagrams could be useful because I know personally that sometimes I work better when I have the thing in front of me. For ones like probability where you have a certain amount of coins or balls . . . having that in front of me would definitely help. But for others, I think it's fine (CL5).*

However, they were also impatient of diagrams that might mislead:

*There was a question yesterday in our paper . . .it was like a diagram but, and the angles were different sizes, but the smaller angle was bigger, the big angle smaller. But it made me think I'd done it wrong, because on the sides of the diagram it didn't say whether it was drawn accurately or not (CL6).*

Importantly, learners who had experienced, or were experiencing, a range of other approaches to summative assessment during the pandemic were quite sophisticated in their analysis of the affordances and constraints of those, again functioning as curriculum narrators:

*Perhaps use a mix: exams are the only really fair way, but they could perhaps have a contribution from teachers, to incentivise hard work and give students confidence that not everything depends on that eon day (EL4);*

*(Centre-assessed grades were) completely unfair in some ways, there should have carried on with exams, in a socially distanced manner or invigilated online—grades have to be earned not given, if they're going to be respected (EL5).*

Such issues are further explored in [30]. More broadly, the majority of 14–18-year-olds and up to about 30% of younger learners made relatively independent and selective use of the funder's (and a range of other) resources. These included freely available digital curriculum apps and online fora they chose for complementary mathematics support or enrichment:

*Different online resources are useful for different topics, depending on how secure I am, I can choose what works best to improve (CL7);*

*Looking back, I'm now much more selective of whether I use apps or an online room: there are places that are good for consolidation and others that really help if you want to know a bit more, beyond what the exam needs (DL4);*

*I can rewind videos teachers record and learn at my own pace' (Ey12L6);*

*I created a study group where we would all join a Teams meeting and do maths questions and topics. . .. (That) helped all of us in revising and maintaining productivity (Ey13, L7).*

These students, who crossed demographic and prior attainment boundaries although they were dominated by higher-attaining students, could be considered to act as 'narrators' of curriculum. Some students also functioned in a variety of other policy roles: the weakest-attaining quartile often functioned as 'survivors' or 'critics', but another (approximately) 10%, particularly those supported to attain highly at either 'tier' of entry, functioned as 'translators' or 'enthusiasts' in Ball et al.'s (2011) terms. Importantly, analysis of learner-sourced data in each element of the study led directly to changes in funder curriculum and assessment materials. It also fed into evidence underpinning central (Ofqual) guidance that developed over time and resulted in key changes to GCSE and A-Level mathematics papers. Details are given in a range of funder-internal reports, but changes included the use of more space and simpler language in younger learners' books; enhancement of the quality and quantity of problem-solving in resources for 11–14-year-olds; accessibility and structure of examination papers at age 16; and an enhanced range of support resources for A-Level Mathematics preparation. An additional, strategic and cross-cutting impact has included greater central exemplification of intended curriculum changes, and central addressing of specific teacher development needs identified [17]. Such changes are especially important in a system where direct use of student voice has historically been accorded only a very low profile.

### *4.2. Teacher and Learner Lenses Compared*

Throughout phases, lesson observation, teacher interview and student focus group data taken together showed fairly close correlation between teacher discourse and that predominantly presented by their learners, although the ~5000 learner surveys showed small-scale (up to about 10%) contra-discourses evident in almost all study classes, underlining the importance of large-scale as well as more in-depth small-scale data collection, and possibly also privatised, as well as shared, narratives. Teachers who embraced curriculum intentions at the classroom level almost always sought resource support for doing so, but functioned as active agents in developing enactments for their classes:

*(The teacher) took some of the structure out of the question, to enhance the challenge; she later explained she thought they could cope with a harder question than in the book, and wanted them to experience getting stuck—as well as having more than one possible solution (Cy8LO).*

Their learners largely talked positively about challenge, identifying aspects of curriculum/assessment-related materials that supported that, and often offering proposals for further resource development:

*The book is pretty good, but the question we had today was harder than what was already there. It took several of us to work out how to do it, but I think that's good—the book does encourage you to work together, but perhaps if there were starred questions that were particularly challenging, that would be even better. Those can be really rewarding, but it's also good if you feel OK if you can't do it' (Cy8L8).*

Other teachers, in contrast, sought ways to 'survive' in the new curriculum and that too was largely mirrored in their learners' discourse—in all phases:

*Since the new practice papers have been published, we don't do the reasoning questions in the book. In principle, I was in favour, but my students found them really hard, and if they're not going to be in the exam, it's not worth the effort (Cy10T1);*

*We don't do all the questions in the book, because the reasoning ones, and some of the problem-solving ones, are too hard (Cy10L9);*

*A lot of learners are finding it incredibly difficult to access the material. So I give them more structure and hints, and train them to recognize where they can pick up a mark or two—we don't attempt the real question (Dy11T3);*

*We're doing OK: Miss tells us what words to look out for, and where we can pick up enough marks. We can usually get enough (for the target grade) without having to go near the last few questions, provided we are careful to get what we can earlier in the paper (Dy11L5).*

Analysis of teacher and learner talk, as above, exposed the hegemony of assessment materials, particularly at upper secondary level, and it was here that the alignment of teacher and learner responses to curriculum change was most obvious. For secondary cohorts 3 and 4, if teachers adopted a procedural approach with learners expected to achieve only poorly on papers, this focus appeared transactional and their learners were generally presented as receivers, although there were exceptions evidenced in every study class: peers who were matched for prior attainment but entered instead for papers on which they realistically expected to perform well, who normatively appeared to thrive, seeking peer or material support and talking confidently about using mathematics post-16:

*We shouldn't be entering them for papers they can't be really successful in, just so they might get a higher grade: . . . I think that's child abuse. I'd rather they got a better appreciation of the maths they can do and not the maths they can't (Dy12T4);*

*I only did the Foundation papers, but I did quite well on those, and now I'm studying Core Maths, there are some new ideas, but that's OK, because they're quite useful for what I want to do, and I'm getting more confident I can make sense of some of the harder ideas (Dy12L1).*

At A-Level, surveys showed similar initial relationships between teacher and learner perceptions. This was exacerbated when successive iterations of the new assessments, especially around problem-solving, posed what several teachers called 'moving goal posts' [14]. Where (about half of) teachers were confident to attribute such change to the challenges of assessing new aspirations, their students of all demographics and previous attainment levels were generally phlegmatic about the varying demands they encountered in emerging papers:

*It's a bit challenging, since we can't be too definite about expectations with the students. But I just tell them, focus on understanding the maths, and then show the examiners what you can with with whatever they choose to ask you (Ey13T3);*

*They seem to be changing their minds about just how hard they're going to make the problem-solving, but that mirrors life and it's all good experience. In a sense it doesn't matter how difficult they make it on the live papers, we'll all be in it together and whatever, it does make you think with your maths (Ey13L26, same school, accompanied by nods from peers).*

Where, on the other hand, teachers reported, or communicated, feeling oppressed or overwhelmed by such demands, students usually seemed unconfident to deal with such variation: *'We now have no idea what to expect, which really doesn't seem reasonable, and it does mean it's not worth investing too much in getting to know the new specs' (Ey13T7); 'We're now really worried because we don't know what they'll be asking or if we've prepared in the right way' (Ey13L42, same school).* However, although again, there were exceptions to that (alignment, for example): *'The teachers aren't sure what will be wanted, but I think you just have to get on and deal with that uncertainty: we only get the one chance' (Ey13L45, same school).*

As the A-Level study continued, learners appeared to retain confidence in their teachers, but, over time, many also developed greater proactivity in independently selecting materials and strategies to match their emerging perceptions of assessment demands. They often framed such actions in terms of the 'exchange value' of the qualification, for example, its use in supporting access to their target university course, whereas teachers' concerns were more focused on learning the mathematics, including for future use, apparently less conscious of the qualification's role as gatekeeper to future career pathways. It would appear that while assessment systems in themselves might be insufficient to drive challeng-

ing curriculum reform within a high-stakes context, they are harnessed and influential in myriad ways.

Data showed that older learners were generally more confident, and better equipped, for proactivity in meeting learning needs via peers, older friends, siblings, and digital resources, and divergence from teacher recommendations. A-Level learners also showed other divergences from teacher standpoints. They perceived *mathematical* demands in their courses to progress fairly smoothly from pre-16 learning, but with a step change in *workload*; given revised curricula, their teachers in contrast were often still struggling to accommodate new expectations of the subject and subject pedagogical functioning.

Taking these two areas together, we see that many learners were themselves active in policy interpretation; they also significantly influenced both teacher and edu-business implementation: this study therefore supports a fairly nuanced conceptualisation of learner as mathematics curriculum policy actor.

### *4.3. Edu-Businesses as Co-Constructors of Curriculum with Teachers and Learners*

The funder edu-business as policy actor influenced implementation in all study classrooms via their curriculum and assessment resources, and as above, those resources served as narrators, enthusiasts, and sometimes entrepreneurs of the mathematics curriculum. For both teachers and learners, the textual hierarchy, in this high-stakes assessment environment, was dominated by their published examination papers for ages 16 and 18 as classes approached those examinations. However, the cross-phase nature of the study revealed that for our sample, the dominant edu-business role for about 80% of our primary teachers—and at least half of primary learners—was as highly influential narrator, sometimes perceived as enthusiast, via their curriculum materials.

However, that did not mean that all teachers in a school responded to the new curriculum, or used the focus funder resources, in the same way. The school mathematics lead/Head of Department was observed very often to act as lead policy actor, whether as narrator or enthusiast or in a less positive role—and was typically influential on practice at least partly via the school mathematics 'scheme of work': *'So when I'm planning, I start from the scheme of work our maths coordinator put together, and I try to stick to that in principle because then the children get reasonably consistent experiences over time, but I tweak it to me, and the particular children in my class' (A17, T5).* However, analysis of lesson plans and observations, as well as teacher interviews, showed individual teachers within a school responding differentially, one with perhaps minimal compliance and another with deep investment in being able to understand, select from and adapt materials for their own learners. The longitudinal nature of the studies meant that we could observe teacher change in practice over time. Almost always, for the (approximately) 50% of teachers who showed significant progress towards the intended curriculum practice over the course of the studies, this appeared to require considerable and sustained (at least eighteen months') investment in rethinking practice with the support of at least the focus materials.

That was true in a fresh way during the pandemic, when the new constraints widely catalysed a re-thinking of primary teacher curriculum priorities and inter-dependencies in which curriculum materials, and particularly teacher guides, appeared to support transformational change in the subject and subject pedagogical knowledge and practice for about a quarter of participating primary teachers:

> *The teachers were saying how much they've gained from re-thinking their planning . . . for doing it online, using the Teacher Guides: they've come to look at things in new ways and had to sort out the main points, so they've now got a better structure, and better priorities, in their heads. And our formative assessment has become absolutely central to our practice: are the children bringing what they need? If not, then we need to nurture that before we can build on it (By4T1);*

> *I keep getting these 'lightbulb' moments where the maths suddenly makes more sense, because I've had to go back and sort out from the materials what are the absolute essentials,*

*what are the building blocks for that, and how will I know whether the children have 'got it'—and my teaching is in a different place because of that (By6T2).*

Longitudinal data showed that this was also true, if less prevalent, in more 'normal' times. In our sample, though, that happened only when teachers invested over a sustained period, and usually, collaboratively, in getting to know the curriculum materials, and particularly, the teacher guidance. In contrast, prevailing secondary curriculum—and assessment—materials did not seem to have that role: curriculum materials acted as narrator and translator of the intended curriculum, supporting teacher roles as narrator, receiver, and transactor—and sometimes receiver of policy—but even for teachers of lower secondary learners not teaching examination classes, we saw little evidence of curriculum materials catalysing significant, and certainly not transformational, subject knowledge or pedagogical quality change over the pandemic period. This was also true of assessment materials, though, as above, the ways in which, and the extent to which, they assessed the curriculum did frequently catalyse change in curriculum coverage and emphasis.

The influence, of course, occurred in both directions: funder-enhanced understanding of teacher and learner perceptions has already served to develop resources in ways that participants find helpful. In a marketised context for both curriculum and assessment materials, that is likely to support market share, as well as to inform edu-business interactions with policymakers.

## 5. Discussion

This study evidences conceptualisations, contrasts and synergies of teachers' work with curriculum and assessment resources in relation to curriculum planning and realisation, but also a range of curriculum-agentic roles adopted by learners, and the interplay of those with teacher and funder resources. It shows how many learners in this sample interacted very actively with their teachers and with curriculum resources to impact curriculum implementation. While teachers were clearly very influential on learner attitudes, in alignment with much other evidence [34,35], that relationship was often quite subtle and counter-discourses were evident in every study class. Both teachers and learners operated, differentially, with a hierarchy of texts often driven by agendas of performativity and accountability—and in which edu-businesses have to be complicit in order to thrive. However, this study also evidences, across phases of education, very constructive agency of some of each of edu-business, teacher and learner in forging meaningful and empowering interpretations of curriculum. In doing so, it exposes learners as potential policy actors in a range of proactive roles, and across phases. It therefore initiates a theorisation of learner as policy actor. It illuminates a range of curriculum-agentic roles of the sample learners, as well as the interplay of those with teachers and with the funder resources. Importantly, our data showed student policy role proactivity across demographic groups, although somewhat more common among students with previously relatively high attainment. Student proactivity was also somewhat associated with teacher proactive curriculum roles, across phases, as might be expected from some other evidence [35]. It is clear there is potential for learners to play a more active role in curriculum development at all levels, including in the design of curriculum resources and assessments, but also potentially in the development of the intended curriculum.

Our approach exposed an underlying and emergent (social) co-construction of meaning-making in relation to curriculum and related processes at the school level, as teachers and learners came to engage with the content, framing and structures of the variety of texts associated with the revised curriculum, with their implicit messages about agency and responsibility. Of course, researchers' own curriculum documentary analysis also drew on subjectively communicated tenets of policy, of policy development and of intended practice. When this was complemented by classroom observations, teacher interviews and learner focus groups, we were able to evidence how teachers and learners accounted the received meanings. Surveys for older learners then contextualised and further validated focus group and individual teacher responses, though offering co-constructed 'snapshots'

only. Those featured as key influencers often included the school mathematics lead for teachers and usually included the class teacher for learners. Those influencers appeared to vary in their policy-coherent capacity, beliefs and commitment to a solution focus.

The institutional ethnographic approach focuses on power relations, including inter-textual relations, and beyond our focus, participants of course described other sources of influence (and power), including school management and learners' parents, that we did not explore here. Funder resources exerted power in a number of ways and to a variety of extents, but in the vast majority of sample classrooms, they functioned as active social agents rather than static sources—in line with some other evidence in the field [25,36]. GCSE (age 16) and A-Level (age 18) assessment documentation almost always proved hegemonic in inter-textual hierarchies, even if that power was then mediated by teachers and/or learners: the meanings made by secondary teachers and learners were often dominated by those texts, leading to marginalisation of some aspects of other materials, where users perceived a limited coherence with either edu-business or their own assessment priorities. It is therefore critically important that assessment materials are designed so as to support the intended curriculum as far as possible. It is worth noting, also, that while study learners appeared to be significantly influenced by their teachers' communicated values, including being receptive to the roles of meaning-making, rigour and challenge in mathematics where their teacher promoted those, their own values did not always align with those of their teachers. For example, for a small minority of learners, achieving the grades they needed to meet university offers, even if that was for a mathematics-intense course, appeared more important than mastering the mathematics involved. Where teachers are aware of such tensions, they could perhaps harness those to achieve a synergy of their own and their learners' values. Similarly, it is useful for teachers to be aware that recently revised curricula are not necessarily an issue for learners, provided that teachers are supported, including via appropriate materials, to communicate confidence and clarity around the related changes: what can represent a challenging change for teachers is the only target curriculum familiar to learners.

The study approach exposed the fragility of curriculum policy coherence, adding to the existing substantial evidence in this area. Implementation was highly socialised and contextualised at several scales, as evidenced by the variation on individual, within-class, between-class and between-school scales, and also over time. Consequently, even our range of ecologically appropriate tools in a large-scale study only suggests subjective interpretations of this complex field. Observed patterns, though, can be helpful for practical purposes, such as developing materials to better support perceived need. Beyond highlighting threats to validity of implementation and pointing to apparently necessary characteristics of the curriculum system, if that is to be achieved, the deeply subjective, contextualised and idiosyncratic nature of individual standpoints precludes research identifying robust generalities, absolutes and deterministic features. The study does, though, offer good evidence that policy-coherent teacher-educative curriculum (and assessment) materials can, with investment of time and energy, support teachers to interpret, respond and enact in ways that align with (or even flesh out) the intended policy objectives. In this case, importantly, that was being achieved directly through the resources, without significant additional support. Policy churn and performativity considerations can, however, undermine that validity of enactment.

*Reflection on the Methodology*

In the reported study, academic–publisher research collaboration supported deeply informed, robust and credible research design. The study's longitudinal nature exposed aspects of reform implementation that would not have been clear from shorter exploration. Classroom closeness facilitated an ethnographic grasp, hidden in other large-scale curriculum implementation studies, of how participants came to act as they did, how that played out in the classroom, both constrained and enabled by other participants, and how institutional characteristics at a variety of scales further shaped that over time. In this

endeavour, though, it was limited as to exposure of power relations, since teachers and learners are also subject to a multitude of other influences not directly explored here. The use of phase- and subject-expert researchers in all fieldwork supported a good grasp of the social context being explored, though clearly, the nature of the research precluded a full immersion in those contexts.

Our data were able to expose roles for learners—in all phases, though overall, more commonly as they matured—as active 'policy actors', including as 'translators', 'constructive critics', and sometimes 'enthusiasts' for the intended curriculum, and the two theoretical frameworks used, of Ball et al.'s [21] policy actor typology, and of institutional ethnography [23,24], provided complementary lenses on that data. Together, these approaches begin to show just why curriculum system coherence is challenging to establish, and even more so, to maintain, perhaps especially in a high-stakes, marketised assessment regime; we suggest it is likely more challenging where, as in this case, those assessments are relatively demanding [10]. Such fragility also threatened to undermine teacher investment in professional development for achieving classroom coherence with the intended curriculum. However, there were also large numbers of classrooms (nearly half, across phases) where observations showed teachers making sustained progress towards valid, if variably effective, enactments of curriculum intentions over time, with curriculum, and sometimes assessment, resources supporting teachers to interpret, respond, and enact them in ways that align with (or even flesh out) the intended policy objectives. Comparable approaches would transfer to other education policy studies that are close to implementation at the policy's target sites.

However, importantly, analysis of these affordances also highlights some fundamental challenges associated with policy implementation research. In particular, teacher and learner implementation of intended curriculum change are deeply contextualised, contingent and idiosyncratic. There were (non-deterministic) associations between teacher attitudes to curriculum revision and their learners', as there were associations between teacher classroom implementation and maths lead intentions, approaches and strategies—but always also minority contra-discourses.

Finally, curriculum revision can create opportunities for reflection on, and development of, practice, but so can research participation, so there is necessarily an 'uncertainty principle' operating in relation to the reflections and enactments evidenced.

## 6. Conclusions

This paper outlines the affordances of harnessing two theoretical approaches to research methodology and conceptualisation of classroom-level curriculum policy enactment, in ways that give rise to complementary lenses on this complex field, enriched further by the possibility of looking at related evidence across phases of education. In doing so, we evidenced many commonalities of response to the curriculum across different phases—including variation in the validity of implementation within each phase (and some mathematically empowering and challenging implementation in each phase). However, performativity agendas often threatened to undermine moves towards validity of implementation. Additionally, research partnership between different policy 'actors', namely the funder edu-business and a lead researcher in a research-intensive university, supported access to information and research robustness not otherwise easily achievable. Application of such strategies to other areas of education policy has the potential to illuminate a comparable range of findings. In particular, we could analyse longitudinal and cross-phase as well as inter- and intra-school level implementation at a deeply informed level. Policy actor typologies supported identification of learners taking a range of policy-active roles, while institutional ethnographic approaches exposed inter-textual hierarchies and the sustained hegemony of texts associated with high-stakes assessments.

We evidenced the edu-business, teacher and learner taking a variety of policy actor roles, including very proactive ones, and mutually interacting to influence the roles of others. In our world of globalised multinationals, it seems likely that edu-businesses will

remain influential in education policy, including in high-stakes areas such as mathematics education. Understanding their roles and interactions with other stakeholders is therefore important. We also identified that while teacher and learner responses to policy are often inter-dependent, learners in all phases were capable of proactive independent assessment and re-imagining of curriculum implementation. We argue that there is considerable potential to harness that creativity better.

The specific findings of this study do not transfer elsewhere unproblematically, since English policy actors are working in a specific, high-stakes assessment context where a single edu-business dominates curriculum and assessment resources in mathematics education. Nevertheless, the methodology is transferable. It affords valuable insights into the complex dynamics of educational policy enactment, offering a fresh perspective that can contribute significantly to the field of education research. The analysis presented exposes a role for using a variety of conceptual and methodological approaches to education policy research, differentially selected and harnessed for complementary purposes, and for inter-actor research collaboration. Together, these support deep longitudinal, cross-phase study, enable comparison of learner and teacher standpoint, and expose possibilities for theorisation of learner policy roles. The paper's contribution is to focus on the intended object of curriculum policy—teachers and learners at the classroom level—highlighting for those purposes freshly developed and fruitful methodological and theoretical approaches for such study.

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