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# What do heterarchical social network approaches to policy research have to offer IRME?

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*This paper addresses the application of heterarchical social network approaches from education policy work to research focused on implementation in mathematics education. Drawing on findings from a set of longitudinal such studies, it develops an implementation sub-network analysis of stakeholder communication and influence within that research. In so doing, it informs the characterisation and probing of the roles of stakeholder roles in our field, with a focus here on education, researcher and both teacher and student as stakeholders. It contributes a novel extension and application of such approaches, demonstrating their potential to inform and explain complex mathematics education implementation behaviours and showing they are generalisable across our field.*

*Keywords: Education policy implementation, social network approaches, stakeholder, nodes, arcs.*

## Introduction (Focus and rationale)

Much implementation research in mathematics education (IRME) is focused on implementation of policy, and some TWG23 papers already adopt theoretical approaches from policy research, for example Coburn's (2003) theory of scaling up an educational reform (Ahl et al., 2022). This paper surveys, at a high level, aspects of heterarchical social network approaches to education policy, considering the application, potential and limitations of those in recent research-based curriculum implementation work. It extends such approaches to focus on the evidenced strength and nature of inter-stakeholder influences within such a network. I draw on a suite of fairly large-scale, cross-phase and longitudinal studies to illustrate the potential of such approaches, showing how they can illuminate relationships between stakeholders, with related explanatory power for IRME.

## Theoretical framework and related literature

Much of our interest in TWG23 is centred on the implementation at scale of research-based aspects of curriculum reform, drawing on sociological approaches: for example, Stein, Remillard, and Smith's (2007) notions of written, intended, enacted, and attained curriculum are drawn on in Century and Cassata's (2016) influential paper. Curriculum implementation research has moved a long way from Supovitz and Weinbaum's (2008) seductive notion of (implicitly linear) 'iterative refraction' as a centrally-codified intended reform experiences successive layers of policy actors' translation to the student in the classroom - to much more nuanced and complex models.

I consider in particular Stephen Ball's Bernstein-informed oeuvre (cf. Lingard & Sellar, 2013), developed in recent years to illuminate the potential of **heterarchical**, rather than hierarchical, **social network approaches to education policy** (e.g. Ball & Junemann, 2012) whereby *nodes* represent (a non-exhaustive set of) policy actors such as central government, school- or local-level leaders, classroom teachers, media, non-education business organisations, academic researchers, consultants,

third space providers such as think tanks, edu-businesses, professional organisations,.... A policy actor here is an enactor or subject of policy text (Ball, 2009), with each actor bringing distinctive knowledge and other resources to the policy field. Network *arcs* represent node ‘intermediaries’ (Callon, 1992) that support communication and influence between actors, and so are conduits for impact. Those include texts, technical artefacts such as machines, tools and technologies, humans and their knowledge, skills and know-how, and money. An example is given in Shiroma (2014).

To what extent can IR unproblematically adopt such approaches? Using the TWG definition of ‘implementation’ (Aguilar et al., 2019), innovation is not policy, though innovators might aspire to their innovations being adopted as policy. Equally, policy may not be research-based - it might not even be particularly research-informed (Brown et al., 1998). Policy is usually conceptualised to have central (national, regional or district) political authorities as key actors; it has to operate, and be seen to succeed, within the relevant political timescales (though outcomes will be framed, and maybe also conceived, as longterm desirables). In contrast, research-based innovation, even at a reasonable scale, might not involve national or regional political bodies, though it often does. It aspires to sustainability over extended periods of time – though impact over shorter time scales will often be necessary to maintain ‘buy-in’ of stakeholders, where I adopt TWG23 agreed usage of IME stakeholders as those with power and agency to influence the focus implementation (Ahl et al., 2022). IME stakeholders are therefore a subset of Ball’s (2009) actors, at least when the focus innovation is adopted as policy. In IME research, I include students as potential stakeholders, with power and agency outlined below. Both IME and education policy research involve a range of stakeholders who, to different extents, for different reasons, and with different motivations, have reason to want to see innovation of some kind implemented in ways they see as valid and sustainable, usually at scale, eventually in classrooms and to some benefit for learning. Of focus in this paper are edu-businesses, conceptualised as private for-profit and not-for-profit businesses with power and agency in the field of education (Ball, 2009).

Implementation involves a *community of the resource proponents* (CRP) and a *community of the resource adapters* (CRA) (Aguilar et al., 2019), each of which can then be conceptualised in Ball’s (2012 and later) way: in contrast to some simpler models, these communities then interact in both directions, with e.g. Aguilar and Castaneda (2022) illustrating very clearly how the politics in each interact. Further, some nodes are in common to the CRP and CPA (diagrammatically, they might be represented in parallel planes, with some common nodes two-dimensional). Edu-businesses can lie in both the CRP and the CRA, but are very often more visible in the latter. Within Krainer’s (2021) three major groups of implementation *stakeholders*, namely agents from *practice*, *research*, and *policy*, edu-businesses might operate directly within both research and policy: below, we see the influence they can exert on stakeholders within practice. Much of the literature to date focuses on the network actors and the existence of arcs between them; in this paper I begin to consider how the nature of what is represented in those arcs can illuminate the relationships, and particularly the influences, between policy actors, when applied to IR – and so contribute to explanations of IME. The focus will be on the application and development of the heterarchical social network, rather than details of the empirical findings per se.

## Illustrative studies

I therefore turn to a set of five linked longitudinal implementation studies to illustrate how Ball’s heterarchical social network approaches can illuminate IME peopling, structures and influences in research, focusing in this case on practitioners (both teachers and students), study academic researchers, and one ‘edu-business’ (Ball, 2009). The edu-business concerned (named in the Acknowledgements) is here designated ‘the funder’ since the focus is not on the specific multinational concerned, but on their role as curriculum reform stakeholder. In England they are a leading publisher of student and teacher mathematics curriculum resources. Additionally, in a marketised school qualification context they are the market leader in the high stakes assessments of GCSE Mathematics, taken by nearly all 16-year-olds in England; also of A Level Mathematics, the principal pre-university qualification for students wanting to study areas with a significant mathematics content at university, and taken by about 20% of the cohort.

The studies took place in the context of a new mathematics national curriculum for years 1 to 11 from 2014, and new A Level Mathematics curriculum from 2017. The policy context was as described in Lerman and Adler (2016), who point to deviation from research findings in some aspects of the recommended pedagogical approaches; nevertheless, curricula featured widely-valued and research-based renewed focus on mathematical problem-solving, reasoning and communication, and building up of positive mathematical affect. Each study focused on mathematics education within one phase of schooling from primary (age 5+) through to pre-university (age 18), and explored how the new curricula were being implemented in classrooms. Each had a parallel focus on how a particular set of the funder’s curriculum resources and high-stakes assessments were being used and experienced, and with what impact on student and teacher learning. Each study class was followed for at least two years, with termly interactions with teachers - and with older students. We made annual whole-day visits to each school, with full lesson observation, teacher interview and student focus group for each of two study classes. Schools sampled were broadly representative in terms of several variables known to influence teaching and learning. Data collection events were as in Table 1.

**Table 1: Implementation study timing and data collection events**

Study	Observation followed by focus group n=	Focus group students n=	Teacher Interview n=	Pre-/post-study student progression data n=	Student surveys n=	Teacher surveys n=
Age 5-11 study 1, 2015-2018	36	142	136	1014	-	-
Age 5-11 study 2, 2018-22	114	470	198	2708	-	210
Age 11-14, 2015-2018	44	138	136	713	785	-
Age 14-16/GCSE, 2015-2019	141	549	265	803	1602	-
A-level, 2017-2021	68	302	104	1846	1786	166

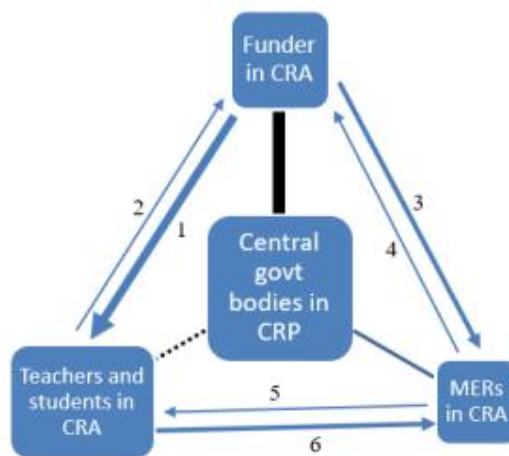
The 2017-2022 A Level study, for example, followed classes from each of the first three cohorts, including the pandemic years, though for 2021 online interactions with teachers and students replaced

visits. It followed 68 classes through their two years of A Level study. The author led all aspects of the research design and implementation, with the funder Head of Research overseeing funder-internal processes. All fieldwork, textual, observation and student voice initial analysis/interpretation was carried out by phase-knowledgeable mathematics education expert researchers external to the funder, including the author. Initial analysis/interpretation of the data was shared between funder and external teams, with cross-researcher validation of a sample of that. The author then led the crafting of the whole into reports, conference contributions, policy briefs and papers. We used an institutional ethnographic approach (Smith, 2005) to design, analysis and interpretation, and a variety of documented approaches to ensure trustworthiness, academic integrity and addressing of potential conflicts of interest. More details of the studies are included [here](#), with further publications in preparation.

One important advantage of a suite of such studies is the potential to see patterns both across studies, and within each. For example, the suite clearly evidences that both teachers and students almost always attributed authority to *proxies* for the intended curriculum – examination papers or printed or digital resources. Edu-businesses such as the funder are therefore highly influential as translators of policy via curriculum and assessment materials, operating in both the CRP and the CRA.

Data offer an illustration of Ball’s theory in practice: the studies themselves are focused on the CRA, specifically on nodes representing the funder (peopled by a variety of researchers, teacher/student product developers, assessment experts...), the mathematics education author-led researcher team (MER), study teachers – and students. In theory, an actor could occupy more than one node. Here, for simplicity, I group teachers and students together since the nature of their communications with funders and researchers proved to be similar and often aligned – though also distinct in some important ways. I include students because of their evidenced two-way influence with both the funder and the MER. Prominent in a range of communications evidenced was a risk of ‘talking past’ (Østergaard & Jankvist, 2022) other stakeholders via discourse that was superficially similar but fundamentally different. The analysis below does not yet extend to the wider mathematics education research community, the personal-, school- or local community influences, or any other of the myriad actors relevant to classroom implementation of a curriculum. However, it does suggest some important explanatory features of such implementation.

Because the model is heterarchical, there is the possibility of influence in both direction between any two nodes, and in Figure 1 below I consider those two directions separately. Additionally, the ‘weight’ of the arcs 1-6 represents a (subjectively evaluated) evidenced strength of impact of one stakeholder on another within the CRA *in the source research*. It is important to note that beyond the research context, those influences often change, and only sometimes in ways that are evident from these or other data, so that there is an uncertainty effect in any such IRME analysis. The strength of communication with central government bodies, functioning almost exclusively within the CRP, could similarly be analysed in terms of strength of directed influence by using directional arcs. Numbered arcs in Figure 1 represent (some) evidenced ‘intermediaries’ of communication and influence as follows:



**Figure 1: CRA influence sub-network operating in sources studies (with communication links to CRP)**

**Funder to teachers/students (arc 1):** textbooks, exam papers and supporting material including intermediate assessments or for primary, interim summative assessments. Funder-produced assessment materials related to high stakes GCSE or A Level examinations were usually hegemonic, for both teachers and students, in implementing the curriculum. Earlier in schooling, funder curriculum materials, designed to be teacher-educative (Davis & Krajcik, 2005) and so potentially influencing all aspects of a teacher’s mathematics curriculum work, were particularly impactful (and sometimes mathematically highly empowering of both teachers and students) where teachers engaged with them in depth and over sustained periods of time, often collaboratively with other teachers. Resources for students were usually mediated by teachers, though older students often engaged with them proactively and in sustained ways.

**Teachers/students to funders (arc 2):** Knowledge of perspectives on the use and impact of resources and of experienced curriculum; money, via teacher choice - mediated by students - of curriculum resources and assessments.

**Funder to MER (arc 3):** Funding supporting research that is scaled across time and phase. Knowledge of edu-business perspectives, priorities, constraints, which inform MER’s policy work.

**MER to funders (arc 4):** Credibility and integrity of research outcomes for funder-internal and external (CRP and CRA) purposes. Knowledge of practitioner communities, of MER and of mathematics classrooms, strengthening interpretation of CRP-intentions for the curriculum within the CRA and sometimes interpreting evidenced teacher or student perspectives to/from the funder.

**Teachers/students to MER (arc 5):** research findings and broader, including knowledge of ‘received’ curriculum, and of school- and classroom-level affordances and constraints, including of their students and their mathematics. These all contribute to MER work.

**MER to teachers/students (arc 6):** Research-led knowledge of focus resources and CRP, of curriculum pedagogy and materials, and of wider related research - but widespread evidencing of these actors ‘talking past’ (Ostergaard & Jankvist, 2022) one another. Of particular concern, across studies, was teacher grasp of mathematical ‘fluency’ and ‘problem solving’ as intended in the new curricula: that frequently deviated from MER interpretation of curriculum intentions.

In relation to the CRP in England, the funder and author, but especially the funder, have direct communications with central curriculum and assessment bodies; teachers and MERs broadly, less so, although there is weak communication with professional bodies. Students are usually excluded from communications in either direction, although recently Ofqual has drawn on student voice around their pandemic experiences (Isaacs & Murphy, 2022).

## Discussion

I have shown that heterarchical social network approaches, suitably developed, can harness findings from empirical studies in IR so as to illuminate patterns of agency and influence within the CRA (and potentially, also the CRP). There are several areas of interest to IME that emerge:

Figure 1 represents influences evidenced during the research process, but illuminates some of the complexities of implementation in mathematics education. The longitudinal nature of the studies concerned, and their combined scope across age phases and resources as well as across school sites within each study, mean there is potential to probe the data further. For example, what do communications within this sub-network tell us about supporting depth, sustainability, spread, and shift in reform ownership – and so, scaleability? (Coburn, 2003). What are the contextual variables impinging on this sub-network that support, or limit, intra-network communications that enhance valid implementation of valued aspects of the intended curriculum?

Figure 1 itself needs further validation. However, it suggests that while the focus sub-network is not hierarchical, some influences are much stronger than others, with the funder taking a particularly influential role in the CRA - largely, but not entirely, mediated by their curriculum resources and assessments, which function as *interpreters* of the intended curriculum for teachers and students. The funder is both well-placed to influence in the CRA, and their products particularly valued there, because of the funder's role in the CRP, which lends authority within the CRA. The analysis suggests there is potential for IME research in further work around the role of edu-businesses, the nature of their interactions in both the CRA and the CRP, and probing of any related issues, building on e.g. Ball (2009).

Note, too, that while Figure 1 represents only a small sub-network as it operated during these studies, it is still considerably simplified: 'the funder' operated as different individuals or groups at different times; the author as research lead enjoyed stronger interactions with some stakeholders than did other MERs; teachers and students, as well as other stakeholders, experienced a variety of other influences depending on their context. Further, the influences documented above, while summarised, are likely far from complete: for example, 'talking past' might be an issue in all interactions – and perhaps especially when it is less recognised by the actors concerned.

Figure 1 also informs our thinking about the role of different stakeholders. For example, the MER here directly influences, and is influenced by, study participants. The lead researcher is active in the CRP, and the study MER chose to collaborate closely with an edu-business as funder, in ways which are not common, for a variety of reasons that might usefully be explored. If we consider a broader in-CRA network that includes the IME researcher community and all mathematics education practitioners and students as two (or three) large nodes, two-way communications are not always impactful (van Scheike et al., 2018), and the role of the lead researcher here, as a policy-practice

‘boundary stakeholder’ heavily involved also in the CRP, is again not common. The network analysis above illustrates the potential of such boundary work.

Finally, we have seen through the work of the TWG to date, that a variety of theoretical approaches can be productively harnessed for our purposes – but it is important also to interrogate the relationships between those, and over time, synthesise where possible, and identify the related tensions, so as to avoid unproductive proliferation of approach: richness of insight needs to be balanced by a certain parsimony of approach if we are to achieve both depth and focus in our knowledge of the field. However, the approach exemplified above does draw attention to important features of IME, both drawing together several strands previously evidenced separately and illuminating, as well as potentially problematizing, the plethora of influences within which classroom implementation is crafted.

## Conclusions

This paper argues for the significant potential for our field of heterarchical social network approaches to education policy research. It begins to exemplify and extend, at a fairly high level, the application of such approaches to IME analysis, in particular offering explanatory insights into the roles of an edu-business and of academic researchers within IME research. At present the focus analysis is in its early stages, but the example sub-network given, while simplified, already underlines the complex nature of IME, and differential strengths of influence within the CRA. It draws attention to the student and teacher as stakeholders in IME, while also pointing to contextual variation in their roles, that impacts communication in important ways. The approach is widely applicable within IRME.

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