Chapter 2
Introduction

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Abstract This section introduces interdisciplinarity in theory, and its conceptualization for policy and practice, with a view to developing the research in this subfield as a cumulative, scientific enterprise. The three chapters are outlined. Then I appeal to theory, policy and practice to re-think the notion of school discipline, and to unleash the learner, teachers, and the schools from discipline.

Keywords Interdisciplinary · Theory · Mathematics

The purpose of this section is (i) to summarise the state of the art, including the three chapters in this section, and (ii) to go beyond and indicate some directions of travel for research in the future, in the theorisation and conceptualisations of Inter-disciplinary Mathematics Education (IdME) for research, policy and practice.

But first, something must be said about the phrase 'for research, policy, and practice'. Any review or summary of literature worth its salt must have a direction or object, and here we have three! The aim 'for research' must be to try to establish clarity about concepts, terms and perhaps epistemology and methods so that workers across the field can speak to each other and accumulate knowledge. In addressing the concerns of interested, especially professional, researchers one might expect a modicum of investment of effort and time to grasp the complexity of the issues. The aim 'for policy' is to provide research outcomes in a way that informs policy concerns, such as how to prioritise, what to legislate, and fund. The aim for practitioners might be more illustrative, offering principles that are enriched by cases, and that engage with reflective accounts of practitioners' experiences, both inspiring and troubled. To achieve all three at once is perhaps impossible and different sections and chapters will be more weighted to one or another aim. But let's 'be realistic, and demand the impossible'.

This section's first chapter by Julian Williams and Wolff-Michael Roth develops a sociocultural, cultural historical account of 'disciplines' that begins in the social division of labour, evolves through various social formations like the guilds, and leads to the modern alienation of academic scholarship from productive labour in schoolified

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institutions whose curriculum is essentially specialised, academic knowledge, and whose product is a stratified, 'classed' potential workforce. This alienation of the disciplines from productive activity (i.e. labour, work, even research) then poses the challenge of meaningful learning of both disciplinarity and interdisciplinarity, which the chapter helps clarify in its various categories.

This chapter also reflects on the meaning of multidisciplinarity outside the academy, in workplaces: this is an important context because here (e.g. in multidisciplinary teams in work places) teams of professionals are obliged to work together effectively even in order to execute their own profession respectably, and this involves subduing (maybe one can say 'sublating' or superseding) their own disciplinary priorities in favour of prioritising the joint objective (e.g. the health of the patient, or the welfare of the child, etc.).

This kind of interdisciplinary working highlights the need for professionals to not only 'know their own stuff' but also to have some minimal understanding of how other professions operate and how to interface with them (Wenger refers to this as 'knowledgeability' in landscapes of practice). 'Knowing about' a discipline in this way is referred to as part of meta-disciplinary knowledge of a discipline, not something that schools teach explicitly, though perhaps learnt as part of an implicit, hidden curriculum. This 'knowing about' certainly involves, for instance in mathematics, knowing when to use a discipline and when NOT to. Unfortunately, traditional curricula do not deal with this concern, or not very well: as a consequence learners may 'learn' that mathematics is really pretty useless, something one does at school, with little purpose or relevance to ones concerns and interests. The chapter then finishes with an argument for unleashing the learner from the disciplines in problem solving, which can only arise from (i) knowing a bit about and having some know-how within the discipline, and (ii) knowing when it is appropriate and when not. The authors use the phrase 'becoming undisciplined' accordingly.

The second chapter in this section by Alicia Venegas adopts Sfard's Vygotskyan perspective on discourse and knowledge called 'commognition', which holds that thinking, knowing and knowledge are to be understood as discursive 'communication'—with others, and then also with oneself. In this perspective, a 'discipline' is a discourse, or has a discursive structure (defined by keywords, signs, routines, and endorsed narratives of truth); and working across disciplines involves a sort of integration of the discourses involved, e.g. by translation between two different language structures. In order to illustrate this concept of interdisciplinary integration, discourse from a team of mathematics students and music students is analysed. The team is collectively engaged in making stochastic music, where a set of random variables with appropriate probability distributions decides the number of fingers, notes, pitch, and octave of a random unit of sound. The need to speak of this set as a unit led, through gestures and exploratory talk, to a special, invented term "baggie"—meaning not just a musical sound but also, simultaneously, a mathematical set of random numbers. Importantly, when the mathematicians talk of a baggie they are thinking of its mathematics, but the musicians think of it as a musical chord (actually there is a moment where it becomes natural and desirable to work on two 'baggies' to represent the left and right piano hand).

This line of research has important conceptual elements that draw on Vygotskyan theories of language and communication, but also resonates with the third generation of activity theory discussed in Williams and Roth's chapter: clearly the baggie is a boundary object that manifests the contradictions between the two communities meanings that are held to be developmental. To Vygotsky one might add Bakhtin. The discourses of Sfard might usefully be thought of as language genres in the Bakhtinian sense. Then one would note the significance of the national language which services these different genres and in particular support communication in multiple genres and discourses (hence 'heteroglossia'). The 'boundary object' called a baggie thereby becomes a hybrid word, animated by two distinct discourse genres. In this chapter's case, communication across the discourses is facilitated by the common language of Spanish, but also notably that of gesture.

In the third chapter in this section, Russell Tytler and colleagues discuss integration in a different sense and context, using cases of interdisciplinary projects in schools involving Science, Technology, Engineering and Mathematics (STEM). The lessons from these practical experiences are drawn out in the chapter's coda, and align well with the previous literature (e.g., Williams et al., 2016) in terms of the affective outcomes, and even of the dangers of mathematics becoming routinised into a mere 'tool' for the problem solving by science and technology. The cases show how mathematical creativity could be a significant part of the problem solving, and thus maintain the 'epistemic integrity' of the subject within motivating interdisciplinary contexts.

But also, there is a substantial emphasis here on caveats regarding the amount of planning work, support from the institutions' management, and even outside expertise needed. At the heart of these practical problems, I would argue, is the fact that schools are not really built for interdisciplinary curricula and pedagogies (and I even mean 'built' in the architectural sense, as well as metaphorically in the policy, professional structure, and curriculum and assessment imperatives in the system). This is reminiscent of the observation of a female engineer that the boots offered to visitors on the building site were always too big: in general, the infrastructure emerges historically in ways that are not fit for the purpose of today's tasks; and we are, as Marx observed, condemned to make history with the tools bequeathed us by history. Thus, the institution requires that every project has to be 'open' to student creativity and inquiry (engaging motivation), and yet planning has to ensure that there will be an element of new disciplinary (including mathematics) learning of the appropriate kinds and levels laid down in a pre-historic curriculum (and pedagogy, and …). This has been called 'pushing water uphill' (that is, not impossible but eventually exhausting, according to Sisyphus).

Imagine an education where there is space for teams of students to simply identify problems of interest and then work on them, with a raft of expertise on hand to help where necessary. Then, how would the curriculum be specified, taught and assessed, and how would teaching or expertise be made available in the right forms and places, and at the right times? I think this is a useful question, as it provokes imagination of educational activity led by inquiry and engaging interdisciplinarity, but not artificially so. Mathematics and other disciplines would have to fight for space in a busy field of

knowledge and know-how. The contradictions between alienated disciplines would still be present, but the institutional order would be upside down. The outcomes of the traditional curriculum are strata of people classified by multiple grades in separate subjects and disciplines, but in the upside down university and school, the outcomes might be problems solved, and problem solvers educated by and with a variety of productions, inscribed on their CV, although perhaps with disparate skills and knowledge.

In a previous 'vision' project some of us explored this possibility for the Royal Society of London: this vision remains available online five years later for the interested googler, but apparently untouched and unremarked upon by any serious educational policy maker that I am aware of. Well: why would anyone be surprised?

Reference

Williams, J., Roth, W.-M., Swanson, D., Doig, B., Groves, S., Omuvwie, M., et al. (2016). *Interdisciplinary mathematics education: State of the art*. Cham: Springer. https://doi.org/10.1007/978-3-319-42267-1.