Chapter 1

Introduction to Interdisciplinary Mathematics Education

Brian Doig and Julian Williams

Abstract The purpose of this chapter is to preface, and introduce, the content of this book, but also to help clarify concepts and terms addressed, set the stage by summarising our previous work, and issue some caveats about our limitations. We will close with a discussion of the mathematics in *Interdisciplinary Mathematics Education* (IdME), which we see as a lacuna in the literature, and even in this book.

Keywords Interdisciplinary · Mathematics · Education · Introduction

1.1 Origins and Context of This Volume

The origins of this book emerged after some of us were invited to lead a Topic Study Group (TSG-22) at the International Conference on Mathematics Education in Hamburg in 2016 (ICME-13). Initially the suggestion was for a topic on *Science, Technology, Engineering and Mathematics* (STEM) education, a topic that has been increasingly prominent in educational policy, and practice, in the last decade. However, we preferred to go to the concept of ‘interdisciplinarity’ as the focus of interest for several reasons. First, while much STEM-related work does involve interdisciplinarity, much does not—it had emerged as a funding priority, and is often related more to political and economic expediencies, than to educational principles. Second, much STEM work does little to emphasise mathematics, and when it does so, it does not always relate the mathematics to the other disciplines or subjects involved. Third, much good interdisciplinary mathematics involves non-STEM disciplines, and we wanted to include the arts, music, and other disciplines that might be excluded from STEM. Finally, however, we hoped that “Interdisciplinary mathematics education” would include much STEM work, and even most of STEM work, that might be of contemporary interest.

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1.2 The State of the Art in 2016: What Next?

Prior to the ICME-13 conference, the organisers were invited to produce a *State of the art* in the topic, which was published immediately prior to the conference, and is available freely on-line (see, Williams et al., 2016). This provided the base level of knowledge that all papers in Topic Group 22 built on, and many of the chapters in this book refer to it, so it is worth summarising some of its key points here.

In the *State of the art*, the authors make clear that previous research in the topic suffers from several key problems, or even flaws. First, there is confusion over the key concepts and terms, making it hard for research to become cumulative. Much of the writing in the topic assumes that a discipline equates with a school curriculum subject, and that any form of collaboration, or integration, between subjects is therefore ‘interdisciplinary’, whereas, we prefer to use the term ‘curriculum integration’ or ‘subject integration’ in such cases, unless there is, also, a clear case of interdisciplinarity, i.e. of distinct disciplines working together at some level (more of these ‘levels’ later). *The State of the art* addressed this concern, and this is further developed in this book, particularly in the first section. However, we will have to face the fact that the term ‘discipline’ has multiple uses, meaning somewhat different, though overlapping, things inside academia, and outside it in workplaces. In places such as health services, for example, multi-disciplinary teams tend to refer to teams involving distinct *professions*; some of which may arguably have an academic discipline, or two, in their background training, but the academic disciplines involved do not determine the profession. The inter-professional education being promoted there does, however, engage with many of the issues involved in academic ‘interdisciplinarity’, then, but the concepts involved are different.

Second, the practices involved in schools and tertiary institutions that are quite reasonably described as interdisciplinary, may take a number of forms, and empirical researches into these practices do not often make clear what form they are studying. Again, this makes accumulation of knowledge difficult, and meta-analyses almost impossible. A particular concern comes when these practices are studied empirically, using measurements of learning outcomes; the learning out-comes rarely, in fact, correspond with the interdisciplinary learning outcomes that might have been anticipated or that motivated the practice in the first place. Studies that use traditional test scores in mathematics as an outcome measure, for example, might produce disappointing findings, because the traditional measures are not designed to measure what interdisciplinary practices are designed to develop in learners.

Nevertheless, empirical studies have consistently shown that the raft of school practices, called interdisciplinary, have positive impact in at least one respect—that is the attitudes of teachers and learners to these innovative practices, which usually involve the disciplines being called upon to help learners solve problems in some sort of inquiry classroom practice. It is difficult to extract this dimension, which also is clearly present in the mathematical modelling literature, from the fact of interdisciplinarity as such.

Third, the literature is awash with case study descriptions of practices, usually motivated by enthusiastic practitioners. These are valuable for other practitioners with similar enthusiasms, in helping to prepare them for the possibilities, including opportunities and disappointments, in developing similar practices: there are examples in this book. However, such case studies are doomed to remain local, unless they are accompanied by an analysis of the phenomena of which they are proposed to be a case. Thus, in reviewing this mass of literature, purely descriptive works may make little impact on the field. For this reason, in this book, we have encouraged authors to make a clear statement of the way their work makes a contribution to understandings of policy, or practice, or to the academic literature. Many authors have done so in the conclusion to their chapter.

The *State of the art* in 2016, then, does proceed to offer some solutions to these problems and to this, many of the contributions in the chapters in this book can now be added. In the concluding chapter we will summarise the main additions to the *State of the art* now, in 2018! But here in the introduction, we will prepare you for this, a little, with an advanced organiser.

Most importantly, we suggest, that for the purposes of research, an academic discipline (such as mathematics) be defined in relation to other disciplines which it has developed a division of labour. It is then understood as a cultural-historical formation of practices (such as mathematical practices) that require teaching (hence, disciples and discipline) as a body of knowledge, discourse and skill. Clearly these are at least partly organised in specialised institutions, whose rôle is to build, and, or, develop the discipline as a distinct practice, as well as to protect its particular values, epistemology, communities, and institutions. To this, it is crucial to add, the emotions. All of this means framing disciplinary and interdisciplinary mathematics as a cultural practice, which is inspired by Vygotskian thinking, and Activity Theory.

Implicit in this, however, is the possibility—maybe the necessity—of power hierarchies, alienation, privilege, exclusion, *et cetera*. Indeed the separation of the cultivation of a discipline in (often privileged) academic institutions separated from its practice in everyday life activity almost defines it as alienating and alienated. These features are discussed well, in Bourdieu's and Foucault's *oeuvres* (see again, Williams & Roth, this volume). Indeed, it may be argued, that it is important to understand this sociology in order to challenge unfortunate, or oppressive, disciplinary practices. The formulation of practice as the dialectic of *habitus* and field (i.e., a field of power), or its formulation as a discourse, leads to distinct analyses of power, but they converge on the notion that resistance or challenges to this power require reflexivity, or a meta-awareness of the field, and its discourse.

A major topic to come, then, is one that has hardly been researched in the context of interdisciplinarity, and that is meta-cognition, including meta-knowledge of the disciplines.

1.3 The Sections and Chapters in the Book

The contributions to the ICME-13 conference Topic Study Group included many presentations, papers, and posters, and authors were invited to consider making a full length chapter for this book: their topics fell fairly naturally into four sections. The first section, sub-edited by Julian Williams, on *Theorising and conceptualising IdME for policy and practice*, comprises three chapters. In the introductory preface to this section, Williams summarises these as being theoretical and conceptual, clarifying the distinctions mentioned above and: developing notions of different kinds of discipline and interdisciplinarity (Williams & Roth, this volume); adding the commognitive perspective of Sfard in a case study of mathematics and music (Venegas-Thayer, this volume); and developing understandings of educational policy and practices in a diversity of cases (Tytler et al., this volume).

The section, sub-edited by Pat Drake, a *Focus on cross-cutting skills*, focuses on the state of practice, as experienced by the chapter authors. Drake notes two important, but, perhaps, not surprising, things. The first is that the chapter authors believe, strongly, that it is important to make a coherent contribution to the field. This is because, as the authors suggest, there are as many definitions of interdisciplinarity as there are commentators. This would place interdisciplinary mathematics as a being in a gestational period, not, as yet, a mature field of research or practice. Whether this state of affairs continues, of course, may well be influenced by the present volume, depending on how readers subscribe to the views expressed in this section. Furthermore, if theorists, and researchers, disagree, or at least, do not have a sufficient degree of coherence, practitioners will be left to determine what is possible in school contexts, which may lead, permanently, to interdisciplinarity mathematics education being some sort of hydra, rather than a singular beast.

The second thing that struck Drake, was that the chapter authors had cited, completely different sources, indicating that no one text stands out as defining the field, or, as Drake puts it ‘clearly there are currently no seminal texts, no shared body of work, on which to build our understanding’. This, of course, would further indicate that, at present, we are dealing with a hydra.

This, as Drake says, simply emphasises the need to consider the importance of developing ‘a systematic and international review of the field’, that would support research endeavours with clear, and universally acceptable, foci.

The third section, sub-edited by David Swanson, on *Inter-disciplinarity: Case studies in inter-disciplinarity (mathematics as tool and mathematics as (conscious) generalisation)* looks at, as the title suggests, some illustrative case studies of inter-disciplinary mathematics education.

In his introductory remarks for this section, Swanson makes a strong argument that these chapters can help the reader gain an ‘understanding [that] helps us see how mathematics can be of use in interdisciplinary work beyond its rôle as a tool’. How mathematics has been portrayed, and used, only as a tool, is suggested by a quote from Freudenthal, that claims that school mathematics, in general, has not only cut the bonds between mathematics and reality, but also ‘between mathematics

and itself'. Therefore, interdisciplinarity mathematics, Swanson suggests, needs to start with the bonding of 'mathematics, extra-mathematical reality, *and* between mathematics and itself' in order to create a form of mathematics that can 'dominate and then mathematics could share its full richness within interdisciplinary work', and in so doing, shed its reputation as a mere tool for use with other disciplines.

Swanson found that the chapters in this section emphasised that 'engaging with real world problems (in project work, interdisciplinary problems, or art) brings great benefits for the learning of mathematics'. However, is this really interdisciplinary, or is such project work simply disparate subjects being used as a collection of tools?

The fourth section, sub-edited by Rita Borromeo Ferri, *Teacher education and teacher development* offers 'insight into good teacher education approaches for interdisciplinary teaching and learning'. Borromeo Ferri states that the chapters, in this section, underscore how critical it is 'to make the effects of ... interdisciplinary teaching explicit and transparent for colleagues', which is a point not necessarily taken up by either researchers, or practitioners. Clarity of the nature of one's practice could be a major step in assisting the general understanding of interdisciplinary mathematics. However, spreading the word is not sufficient: there needs to be opportunities for researchers, and practitioners, to explain and debate how, and why, a particular approach *is* 'interdisciplinary mathematics'. However, Borromeo Ferri claims that the chapters in this section 'show that [while] there is a lot of progress in STEM teacher education', there remains a need for teachers who are educated in interdisciplinary mathematics teaching. While this is an obvious point to make, she also adds, that 'we need teachers, who are open minded enough not to see only their own favoured subject or discipline, but who like to connect several disciplines, [and who] discuss their links with colleagues, create ideas and make interdisciplinary teaching and learning lively and motivating for the students'. Whether this is obtainable in the near future, most likely depends upon the influence that these chapters, and others like them, can exert on the teaching profession.

In comparison to previous work such as the state of the art outlined in Williams et al. 2016, this volume builds on and expands the knowledge base of concepts, theories, examples, and studies relevant to this new field. One particular thread that arises again and again from research into interdisciplinarity is the meta-cognition of the discipline of mathematics, and its relations with other disciplines and knowledges. We will pick up this thread again in our concluding discussion, when we finally conclude by asking 'what is still to be done?'

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>.

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