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Reforming Junior Cycle: Lessons from Project Maths

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Introduction

It is well established that the success of any reform depends on the teachers who will access, interpret and enact it (Spillane 1999). The success of the new junior cycle specification for mathematics is no different. While teachers are often referred to as agents of the change process (Kärkkäinen 2012; Schoenfeld 2014), they are also regarded as playing a conservative

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role in educational change by regularly resisting and opposing its introduction (Duke 2004). This is because educational reform brings a certain amount of anxiety and can be very threatening to teachers (Guskey 1986). Implementing a new curriculum often demands major adjustments to their thinking and practices (Orafi and Borg 2009). This inevitably leads to concerns on pedagogical issues such as the reasoning behind the reform, the implications for their classroom practices, the consequences for their students and their ability to implement the changes (Prendergast and Treacy 2018). In the past decade, mathematics teachers in Ireland have been through a major curriculum reform, "Project Maths". The aim of this chapter is to explore what lessons can be taken from this experience considering the further changes brought about by the introduction of the more recent junior cycle specification for mathematics. The focus is on the process of change and on major trends in mathematics education and pedagogy, rather than on mathematical detail.

The first section of the chapter provides the historical background of junior cycle mathematics, setting out reforms that took place from the 1960s. This sets the scene for an overview of Project Maths, which was one of the most multifaceted curricular reforms in Irish education. The following section gives a brief overview of some of the details of the new junior cycle specification for mathematics and outlines the main similarities and differences when compared to Project Maths. Finally, the chapter concludes by exploring lessons for the current reform from recent experiences with Project Maths.

The Historical Context

In the period 1960–2000, there were four revisions of the Irish junior cycle mathematics curriculum, introduced to first-year students in 1966, 1973, 1987 and 2000, respectively. Each change, except for the last, led to a revision of the senior cycle curriculum, brought in after a full iteration of junior cycle had been completed (Oldham 2019).

The context for the *revision of 1966* was set by international trends in the mathematics curriculum, introducing the so-called modern mathematics. This was based on a philosophy of mathematics itself (rather than mathematics education) that viewed the subject as the study of *structures*,

highlighting concepts and their inter-relationships rather than computational procedures. The approach was meant to enhance understanding through emphasis on mathematical coherence (Howson et al. 1981; OECD 1961; Walmsley 2007). The philosophy originally targeted third-level curricula and was not devised for some of the school settings in which it was adopted. In Ireland, the "modern" approach was strongly endorsed by the Department of Education. The reforms at both junior and senior cycle were intended to update content; they also aimed to focus on understanding and to decrease over-emphasis on procedures. Teachers were offered professional development that dealt with the new content but did not address pedagogical issues or the underlying rationale. Thus, the intended focus on structures and understanding in the syllabuses (Department of Education n.d. [1974]) was never fully implemented in many classrooms (Oldham 1980). Moreover, implementation was hampered by a dearth of purpose-written textbooks.

With widening participation in education in the late 1960s and 1970s, the abstract and formal emphasis became less suitable, especially for students taking what was then known as the Lower rather than the Higher course. Rather than addressing the issue, the *revision of 1973* (Department of Education n.d. [1974]) continued the "modern" trend, so pressure built up for further change. The *revisions of 1987* (Department of Education n.d. [1989]) *and 2000* (Department of Education and Science DES 2000) had rather limited briefs, but again aimed to promote understanding; successively, they removed aspects of "modern" mathematics and other material that had proved too abstract or complex for many students. The 1987 revision also introduced what became known as the Foundation level course (Department of Education and Science/National Council for Curriculum and Assessment [DES/NCCA] 2002, Oldham 2007).

Significantly, in the period covering the latter two revisions, and especially after the inception of the NCCA in 1987, there were developments in the *model of curriculum change*. It moved increasingly towards *negotiation*, with the representatives of "teacher" stakeholders, notably the unions and the Irish Mathematics Teachers Association (IMTA), proactive alongside Departmental and managerial representatives on the curriculum development committees (Oldham 1992). For both Junior and Leaving Certificate in the 1990s, emphasis was placed on producing successive curriculum drafts, each meant to be shared by representatives with

their constituencies, with feedback helping to shape the next draft. Final versions were accompanied by documentation on how the new curriculum differed—in detail as well as in general outline—from its predecessor (see e.g. DES/NCCA [2002]). Practitioners had a strong voice in the process. This aided production of curricula that could be implemented faithfully in classrooms, but perhaps caused undue focus on details of inclusions and exclusions and on what might be tested in the state examinations. Moreover, it militated against considering international trends in mathematics education. The growing emphasis on problem-solving, contexts and applications (Herrera and Owens 2001; Walmsley 2007) was not reflected in the Irish curricula, and the style of the state examination papers remained predominantly formal and abstract (Oldham 2007, 2019).

In the case of the 2000 curriculum, the accompanying Continuous Professional Development (CPD) emphasised pedagogy, notably encouraging active learning for understanding (DES/NCCA 2002). However, the intended approaches were not mirrored in the state examinations, which therefore discouraged implementation. Moreover, time allocated to mathematics in the junior cycle was cut in many schools from the envisaged five periods per week (Oldham 2007). Not surprisingly, student attainment in the Junior Certificate examinations did not reflect the hoped-for improvement. This was one factor leading to initiation of Project Maths, described in the following section.

An Overview of Project Maths

Project Maths was an ambitious reform of the Irish post-primary mathematics curriculum and involved changes to what students learnt, how they learnt it and how they were assessed. It was a complete revision that changed both the junior and the senior cycle curricula in a manner not experienced since the 1960s. In the early 2000s, evidence was accumulating that attainment in Irish mathematics education was unsatisfactory. The NCCA produced a discussion paper that examined the problems and identified international trends in mathematics education poorly reflected in the Irish curricula (NCCA 2005). They followed this by issuing a

substantial research report (Conway and Sloane 2006). It noted "a general move towards reform of mathematics internationally as education systems geared up for a globalised economy" (p. 12)—which had an increasing reliance on "cross-border trade, foreign investment, cooperation between governments and international market stability" (Byrne 2016, p. 225)—and advocated a move towards more context-based, real-world and problem-focused mathematics. The economic theme provided a backdrop to the system-level support given to Project Maths and the public discourse around it (Kirwan and Hall 2016); however, detailed curriculum development was guided mainly by theories on mathematics education and pedagogy.

Work took place over a couple of years, reshaping the curriculum in line with a philosophy of mathematics education that highlighted *solving problems, especially those set in real-life contexts*. Thus, the intention was that teaching and learning would emphasise not only conceptual understanding but also real-life applications (to a far greater extent than for previous intended curricula), and that assessment would mirror this emphasis (DES 2013). Rather than following the detailed "negotiation" model of curriculum change from the 1990s, the process gave greater prominence to consideration of research and good practice in other countries; also, by providing less detailed documentation on exactly what might be examined, it discouraged undue focus on "teaching to the test". Nonetheless, the work was intended to be teacher led and student focused. To promote this, a series of ten CPD workshops was run for teachers over the course of the implementation period to explain the philosophy and explore the different pedagogical approaches of the revised curricula.

Following an initial phase that started in 2008 and involved 24 schools, the eventual outcome was a curriculum that was introduced to all other schools nationally on a phased basis from Autumn 2010, as presented in Table 7.1.

The initial phase was intended to allow the teachers involved to play a particularly active role in helping to shape the initiative. The launch of different strands (or topics) over a three-year period aimed to give a gentle introduction to dealing with new pedagogical approaches and also new content where relevant. This allowed for acclimatisation to a changed style of examining. The structure was novel, imaginative and exciting.

Table 7.1 Phased rollout of Project Maths

Phase	Curriculum strands	Phase 1 schools—curriculum introduced	Phase 1 schools—first examination	Other schools—curriculum introduced	Other schools—first examination
1	Probability & *Statistics* and *Geometry & Trigonometry*	Autumn 2008	JC [a] 2011 LC[b] 2010	Autumn 2010	JC 2013 LC 2012
2	*Number* and *Algebra*	Autumn 2009	JC 2012 LC 2011	Autumn 2011	JC 2014 LC 2013
3	*Functions* (and calculus at LC)	Autumn 2010	JC 2013 LC 2012	Autumn 2012	JC 2015 LC 2014

[a]Junior Certificate
[b]Leaving Certificate

However, the intended benefits from the overall approach can be balanced against some problems in the implementation. First, as indicated above, teachers had become used to clear specification of changes to content before new curricula were launched. Also, textbooks had been published in advance of material being taught; sample examination papers had set clear targets for state examinations. The less detailed documentation for Project Maths created uncertainty and stress for teachers and students. Reports released at the time noted teachers' concerns that textbooks were not of a satisfactory standard (Cosgrove et al. 2012; Lubienski 2011), and the IMTA (2012) pointed out several resource-related problems including the late issue of sample examination papers. Secondly, the phased introduction prolonged and complicated the change process. Teachers going from year group to year group needed to switch between different versions of the new curriculum and prepare students for state examinations, the structure of which changed annually. The simultaneous launch of the junior and senior cycle curricula—a break with previous practice—meant that students entering the new Leaving Certificate curriculum in its early years had not experienced the approach that was intended to be developed by the junior cycle. It was June 2017 before a cohort of students (other than the small number in Phase 1 schools) had

experienced all five strands of Project Maths throughout their second-level education.

A substantial overview of Project Maths up to that time, including focus group studies with 76 teachers, was conducted in preparation for the junior cycle reform (Shiel and Kelleher 2017). Early evaluations of Project Maths provided evidence of the positive impact on students' attitudes towards mathematics and their achievement at an individual strand level (Jeffes et al. 2013). However, there were indications of problematic areas. The research identified differences between the intended and implemented curriculum (Jeffes et al. 2013; Prendergast and Treacy 2018); teachers were still "not really 100% sure what to do" (Prendergast and Treacy 2018, p. 138). Teachers' wish for more CPD around the changes was notable (Cosgrove et al. 2012; Shiel and Kelleher 2017). Indeed, a study carried out by Byrne and Prendergast (2019) showed that significant self and task concerns remained among many mathematics teachers even several years after the implementation. Also, in addition to the resource issues noted above, lack of time to implement the curriculum fully was a major issue (IMTA 2012; O'Meara and Prendergast 2018; Shiel and Kelleher 2017). While the examination papers contain more questions than before requiring the solution of extended problems set in contexts, it remains unclear whether teachers and students have really bought into the underlying philosophy or are teaching or learning to the (revised) test without a full appreciation of the rationale (Shiel and Kelleher 2017).

An Overview of the New Junior Cycle Specification for Mathematics

While Project Maths arose from subject-specific considerations, the next round of changes was part of a wider reform of junior cycle. One of the most significant changes brought about by the Junior Cycle Framework (DES 2015) is the move to outcome-based education (OBE). This is a departure from the more traditional content approach to curriculum design used in previous curricula. Such a curriculum is intended to give more agency to teachers but still preserve some control over the skills and

knowledge that students learn. It encourages teachers to be more creative in how they teach their classes, but presents them with a notably increased workload, especially in the planning stage. According to the Junior Cycle Framework, the most significant changes are in assessment. Some classroom-based assessments (CBAs) have been introduced into the certification of student achievement at junior cycle, culminating in the awarding of the Junior Cycle Profile of Achievement (JCPA).

Considering the recent implementation of Project Maths, it is unsurprising that many aspects of the new curriculum represent evolution rather than revolution. The objectives of the old curriculum are now the aims of the new one. The specification divides the course content into mathematical strands similar to those for Project Maths, with four strands covering, respectively, number; geometry and trigonometry; algebra and functions; and statistics and probability. Running across these is a new "unifying" strand, composed of six elements (see Fig. 7.1), applicable to

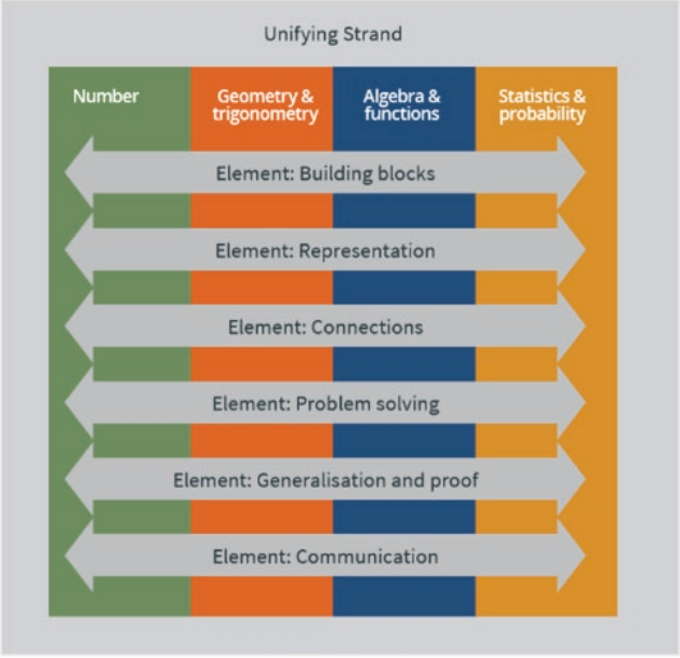

Fig. 7.1 Six elements of the unifying strand. (NCCA 2017, p. 9), with permission of the NCCA

all the other strands. The formulation is an attempt to connect "mathematical knowledge and skills to solve a problem or to communicate mathematics" (NCCA 2017, p. 10) across various topics. Thus, it is in keeping with the key skills set out in the Junior Cycle Framework (DES 2015) and provides an example of how the new curriculum is attempting to embed the principles of connections between topics and the principles of active learning into the written formulation. However, the "learning outcomes" are specific to each of the mathematical strands, and perhaps their full impact on teaching and learning will be seen only through implementation of new aspects of assessment.

The changes in assessment are especially significant for mathematics. The subject never had a coursework element, so this is a major difference between Project Maths and the new junior cycle curriculum. There are two CBAs as outlined in Table 7.2.

As in other subjects, the CBAs will be undertaken by all students and will be marked at a common level by the classroom teacher. In addition, the second CBA has an additional written Assessment Task that will be marked, along with the final examination, by the State Examinations Commission (SEC). The task will be specified by the NCCA each year and will be related to the learning outcomes on which the second CBA (the Statistical Investigation) is based. The Assessment Task is worth 10% of the grade certified by the SEC. A second major change affecting mathematics assessment concerns the final examination. The Foundation level has been removed, and the time allocated to examinations has been reduced: from as much as five hours at Higher level—two papers of two

Table 7.2 Requirements for mathematics CBAs

Type	Detail	Time taken	Completion
Mathematical investigation	Students will follow the problem-solving cycle to investigate a mathematical problem.	Three-week period	End of second year
Statistical investigation	Students will follow the statistical enquiry cycle.	Three-week period	End of first term of third year

NCCA (2018)

and a half hours each—to a single two-hour paper for each of the Higher and Ordinary levels. This raises questions about what content can and will be assessed every year. If certain topics are not assessed regularly, will they be ignored by teachers? Such changes in assessment practices are areas of concern for mathematics teachers. At the time of going to press (late 2020), the first cohort of students taking the new curriculum are only starting third year. However, the outbreak of the COVID-19 pandemic led to the closure of schools in March 2020 for the rest of the academic year, with teaching and learning taking place remotely and, inevitably, considerable time being lost. As a result, many students have not completed their first CBA in mathematics, and those in first year may have missed out on essential groundwork. Temporary arrangements are being put in place for the present third-year cohort, but the full implementation of coursework assessment as originally intended for Mathematics has been significantly set back. Also, aside from the concerns around grading their own students' work for certification purposes, teachers have yet to see sample examination papers, so they are operating in an atmosphere of some uncertainty. Table 7.3 outlines some of the key points of consistency and difference between Project Maths and junior cycle mathematics.

So far, there has been very little research reflecting the current views of teachers about the new junior cycle mathematics specification. As part of a small study, Walsh (2019) ran a focus group on the topic with a group of seven mathematics teachers. He found that some aspects of the changes, such as combining the algebra and function strands, including the unifying strand and the introduction of CBAs, were welcomed. Overall,

Table 7.3 Overview of main aspects of Project Maths and the junior cycle specification

	Project Maths	Junior cycle mathematics
Year of (main) introduction	2010	2018
Introduced on phased basis	Yes	No
Outcome-based education	No	Yes
Coursework assessment component	No	Yes
Simultaneous with senior cycle reform	Yes	No
Simultaneous with junior cycle reform	Yes	Yes

however, Walsh's findings indicate negative perceptions; the teachers expressed concerns about the lack of coherence between junior cycle and senior cycle and the lack of class time for the subject, particularly given the introduction of the CBAs, and were very sceptical about the reduction in examination time from five hours to two. They also believed that the removal of Foundation level does not align with the belief that this new curriculum caters for all students. Walsh's study raises the question of whether the second major curriculum reform in mathematics over a decade may be a step too far for some teachers. Thus, it is important that some lessons are taken on board from the recent experiences of Project Maths, and these are highlighted in the next section of the chapter.

Lessons from Project Maths

The new Junior Cycle Framework represents a substantial change to the traditional philosophy of education in Ireland and is more in line with current international trends in other countries within the Organization for Economic Cooperation and Development (OECD), such as the move towards a school-based curriculum within a central framework and an OBE approach. Priestley et al. (2012) point out that such changes place the teacher at the centre of curriculum development. There is often an expectation that curriculum reform, such as the changes brought about by Project Maths and the new Junior Cycle Framework, will be adopted and implemented without difficulty by teachers in all classrooms (Scheker-Mendoza 2011). This is based on the simplistic assumption that teachers will, machine-like, alter their behaviours because they are told what is good for them and for their students (Handal and Herrington 2003). However, it fails to consider lessons from previous iterations of educational reforms and especially from the Project Maths initiative. Lessons can be distinguished in four areas: the scope of the initiative, the model of curriculum change, features of the curriculum design and aspects of its implementation particularly regarding CPD. They are discussed in turn.

Scope of the Project Maths Initiative

As indicated above, the scope and scale of the Project Maths initiative were much greater than those allowed by the briefs for revisions in the preceding 30 years: revolution rather than evolution. This may well have succeeded better in bringing about meaningful alterations in practice but at the cost of considerable stress for teachers. Moreover, while the aims of Project Maths were desirable for many students, not everyone agreed with the philosophies behind them. Together with some issues in implementation of the reform, these aspects had a negative effect on people's perception of the changes and undoubtedly affected their introduction. This provides overarching lessons; aspects of which are highlighted below.

The Model of Curriculum Change

Several issues are relevant here. One is the *swing away from a focus on negotiation* via *stakeholder representatives towards greater reliance on expert input*. Project Maths made a conscious effort to counteract the limiting effect of the focus on detail and negotiation over successive drafts of the curriculum that had developed in the 1990s. However, this led to limited dissemination of information to stakeholders before and during implementation and contributed to teachers' (and students') anxiety. If the culture of over-focus on detail for assessment has now been broken, perhaps a better balance can be struck in future in keeping participants informed. The involvement of focus groups of teachers, a feature of the current model, is a step in that direction. A second issue is *phasing and alignment*. The phased introduction of the Project Maths strands was not replicated for the new junior cycle specification: perhaps a general feature of junior cycle reform and a consequence of less radical content change than for Project Maths, rather than a lesson learnt. However, the launch of the Project Maths Leaving Certificate curriculum at the same time as that for Junior Certificate meant that the philosophy of the former was poorly aligned to that of the outgoing junior cycle curriculum. This was a major challenge for students and teachers in the lead-up to the high-stakes Leaving Certificate examination. The new junior cycle

specification does present a problem with curriculum alignment, and this is not unique to mathematics; the OBE-style curriculum and the introduction of new forms of assessment mean that it is currently not fully aligned with the senior cycle programme. However, this may alter with forthcoming revisions to the senior cycle. At least, the changes are coming in the more natural order. Thirdly, there were *resource* issues. Project Maths and allied developments around lesson study (https://www.projectmaths.ie/for-teachers/lesson-study-library/) have encouraged teacher autonomy and collaboration with colleagues in creating resources. However, the delayed production of curriculum aligned textbooks and sample examination papers—reminiscent of the 1960s—caused major stress for teachers. For the new junior cycle curriculum, uncertainty around the CBAs and the final examinations at the time of writing suggests that some lessons have not been fully absorbed or applied.

Curriculum Design

Curriculum design involves—inter alia—content, teaching, learning and assessment. The first three and the last are considered in turn. For *content, teaching and learning*, the design of Project Maths and that of the new junior cycle mathematics curriculum reflect similar philosophies of mathematics education and pedagogy, emphasising problem-solving, connections and investigative work. It is widely accepted that, unless content is significantly reduced, more time is required than for expository teaching. Teachers reported lack of time as a major issue for Project Maths, and this lesson may not have been fully applied. The student investigations associated with the CBAs in the new junior cycle will impinge upon class time, perhaps benefiting from double periods. However, a recent study conducted by O'Meara and Prendergast (2018) found that the scheduling of double periods in mathematics continues to be an uncommon practice in an Irish context. This is particularly the case at junior cycle where only 8.9% of mathematics teachers reported a double period on their timetable. One of the achievements of Project Maths was to align *assessment* more closely with the aims of the curriculum, and in particular to break the pattern of predictability that had beset previous attempts—albeit at

the cost of increased stress for students as well as teachers. The trend in alignment is continued for the new curriculum by the introduction of the CBAs. However, as indicated above, at the time of writing there is still uncertainty about their implementation and the shape of the examinations, and lessons may yet need to be fully learnt in this area. As assessment has been one of the most significant areas of teachers' concerns (Murchan, 2018), this should be a particular focus for support bodies such as Junior Cycle for Teachers (JCT).

Support for Implementation

This chapter chronologically exhibited repeated failed attempts in the past to fully implement some curricular aims. This proved to be especially difficult if there was a mismatch between, on the one hand, curricular philosophy and pedagogical intentions and, on the other, the teachers' knowledge, beliefs and assessment practices—especially in the absence of extensive CPD. The introduction of Project Maths did result in increased emphasis being placed on CPD, but teachers wished for more. In the very early stages of implementation, Lubienski (2011) warned that the CPD planned would not be sufficient to facilitate such a substantial change. Byrne and Prendergast (2019) highlighted the importance of CPD and support structures in alleviating Project Maths teachers' ongoing concerns and achieving the intended aims of curriculum change. For the new junior cycle specification, the introduction of the CBAs is a marked difference from the norm for all mathematics teachers in Ireland. The provision of adequate and sustained CPD to support teachers in appreciating the rationale and adopting new practices will be very important.

Summary

The context for this chapter was set by tracing curriculum changes in the 50 years before the Project Maths initiative. Although there were repeated attempts to encourage a culture of teaching for and learning with

understanding, they achieved limited success. The Project Maths initiative aimed at a more radical development. Its model of curriculum change was markedly innovative, and the increased emphasis on problem-solving and applications was supported by changes in assessment. However, difficulties arose from the scope and scale of the developments. While the aims of Project Maths were desirable for many students, there were issues with the style and implementation of the reform, and this led to anxiety and negativity. The recently revised junior cycle mathematics specification shares many features with the Project Maths curriculum, and in many ways has had a smoother introduction; however, the impact of new assessment practices remains to be determined. Familiar lessons can be drawn from the Project Maths initiative; they include the importance of communication amongst stakeholders, the provision of adequate teaching time for faithful implementation, the key role of assessment in realising the changes and the need for extensive CPD especially in the context of changes in philosophy and pedagogy. It is to be hoped that they will benefit ongoing and future reforms.

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