Reflection on Project Maths after Ten Years: To What Extent Have Teaching Methods Changed?

Emma Berry, Aibhín Bray, and Elizabeth Oldham

Trinity College Dublin, the University of Dublin, Ireland

Ten years on from the introduction of the "Project Maths" initiative, this study aims to explore how it may have changed "common practice" in terms of pedagogical approaches within the Irish Leaving Certificate Higher level classroom, and to identify the main factors that influence teachers' choice in this regard. A mixed-methods approach to data collection was implemented using an online survey distributed to teachers using voluntary response and snowball sampling methods. Responses from 111 teachers indicated that direct instruction remains the predominant pedagogy in their classrooms, with perceived time constraints, teachers' level of comfort with an approach and their beliefs about its effectiveness being the predominant drivers of their choices. Results suggest a need for more professional development to increase teachers' level of comfort with the student-led pedagogies promoted by the reformed curriculum, as well as pointing to a need for research into their effectiveness, to achieve the objectives of Project Maths with respect to mathematical proficiency.

Introduction

Mathematics education in Ireland has undergone significant reform in the past dozen years, with a major initiative, "Project Maths", introducing a reformed curriculum initially to 24 schools from 2008 and then nationally from 2010. In both cases, the changes were phased in over three years concurrently at Junior and Senior Cycle. This was the first comprehensive curriculum reform in post-primary mathematics for over 50 years, aiming to change not only the content, which had evolved incrementally over the period (Oldham, 2019), but also the pedagogies and students' approaches to mathematics. It emphasised developing competences in solving problems in both familiar and unfamiliar contexts, via a more student-centred approach that would enhance engagement by focusing on investigative learning pedagogies (Byrne et al., 2021; National Council for Curriculum and Assessment [NCCA], 2013).

Just over 10 years since the national rollout began, a point has been reached where the students in the final-year cohort have experienced only the new curriculum. Teachers should also be familiar with it. The aims of the present study are *to establish what is "common practice" in terms of pedagogical approaches within the Leaving Certificate Higher level (LC HL) classroom*, and *to identify the factors that influence the use of those pedagogical approaches*. The decision to focus on Senior Cycle is due to:

- The introduction of a new Junior Cycle specification for Mathematics in 2018, with greater emphasis on learning through problem solving (which could confound the research, as current Junior Cycle practice may reflect this rather than Project Maths)
- The possibility of forthcoming changes to the Senior Cycle, for which feedback on the present situation could be relevant
- A study by O'Meara and Prendergast (2018), highlighting a lower level of satisfaction with time allocation for mathematics at Senior Cycle than at Junior Cycle

This paper outlines factors that led to introduction of the Project Maths initiative, setting them in the context of international trends in mathematics education. Key aspects of intentions and implementation of the initiative are highlighted. The methodology and findings of the study are presented; conclusions are drawn and possibilities for further work are set out.

Background and Context

Consideration of outcomes appropriate for students learning mathematics, and of the classroom practices that might best achieve these outcomes, produced lively international debate in the 1980s and 1990s. An important definition of "mathematical proficiency" emerged in 2001, specifying five intertwined "strands": conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (Kilpatrick et al., 2001). Thus, it became relevant to look for classroom practices that are especially powerful in promoting the different elements of proficiency (Groves, 2012).

Another international movement focused more broadly on curriculum. Throughout the 1990s and 2000s, there was pressure for mathematics curriculum "reform". A range of factors contributed: disillusionment with the level of abstraction in curricula; concern about students' limited capacity to apply taught material to new contexts; research from the learning sciences redefining best practice; and pressure generated by studies such as the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) (Conway & Sloane, 2006). Emphasis on "realistic" problem-solving gained popularity. Curricula in the so-called "reform" tradition are designed to focus on solving problems set in contexts, especially those relevant to the learners and their experiences (van den Heuvel-Panhuizen & Drijvers, 2014).

Many of the factors giving rise to pressure for change were pertinent for Ireland (Conway & Sloane, 2006). While much of the "modern" material adopted enthusiastically in the 1960s had been removed via successive revisions, curriculum content, especially for Higher level courses, remained rather "pure", as indeed it had been before the "modern" innovations (Oldham, 1980, 2019). Curriculum documents prior to 1970 did not specify learning intentions, but all later ones – albeit using differing vocabulary and formulated in different styles – focused on conceptual understanding and procedural fluency; some heed was paid also to strategic competence (solving problems) and adaptive reasoning. However, questions can be asked about the extent to which the intentions were implemented.

For years, there was a strong perception that a narrow form of procedural fluency remained the focus in many Irish classrooms, with (in Skemp's (1976) terminology) rules given without reasons, and with rote learning encouraged particularly by out-of-field teachers and those teaching lower-attaining students (Oldham, 1980, 2001, 2019). Hard evidence about classroom practice was elusive until 1996. Then, the results of the initial round of TIMSS ("TIMSS 1995") showed that expository whole-class teaching was the norm, group work was rare, and many Irish teachers prioritised the lower-order objective of remembering formulae and procedures over higher-order ones involving logical reasoning, creativity and application to the real world. The findings are nuanced, but – taken in the context of other factors – they suggest that this reflected teachers' beliefs, not only about the nature of mathematics as a

subject, but also about the ways in which it is best taught and learned (Oldham, 2001). Supporting evidence came from an in-depth video study of twenty Junior Cycle mathematics lessons. In these classes, "[learning] appeared to be defined as a matter of memorising procedures and facts…. The objective was to ensure that students perfected their procedural skills" (Lyons et al., 2003, p. 143). Altogether, therefore, in the early 2000s the moment arrived for Irish post-primary mathematics education to be reconceived in the "reform" tradition, rather than incrementally revised. This led to the Project Maths (PM) initiative.

The PM Reform: Aspects and Implementation

The PM curricula were intended to build competences in solving problems in both familiar and unfamiliar contexts, thereby increasing learners' aptitude for logical thought and mathematical communication (NCCA, 2013). The approach was underpinned by the belief that emphasis on solving context-driven or applied problems would encourage higher-order thinking, promoting development of students' abilities to deal flexibly with problems and see connections between concepts (Johnson et al., 2019; Pegg, 2010). Eventually, the strands of mathematical proficiency were adopted as objectives (Kirkpatrick et al., 2001; NCCA, 2013).

To achieve the goals of the reform, changes were required, especially in pedagogy, textbooks and examinations (Conway & Sloane, 2006). A more student-centred pedagogical approach was advocated, with an emphasis on investigative learning in realistic or applied contexts: hopefully shifting teachers' focus towards conceptual understanding and strategic competence (cf. Groves, 2012). The move was supported by significant changes in the style of the examinations and by substantial professional development (Byrne et al., 2021; Johnson et al., 2019; O'Meara et al., 2017). Some content was removed to allow more time for active methodologies (Johnson et al., 2019). Overall, it was hoped to bring about more faithful implementation of the PM curricula than had been the case with earlier reform efforts. Separately, encouragement for greater uptake of LC HL was offered by the award of "bonus points" for university entry to students achieving suitable grades (Cosgrove et al., 2012).

Research to date has pointed to less than full adoption of recommended pedagogies. Early studies found that, although there was evidence of support for the constructivist and "reform" approaches encouraged, "traditional" teaching was still widespread (Cosgrove et al., 2012; Jeffes et al., 2013). More recent work by Johnson et al. (2019) indicated that the situation had not greatly changed; teachers were unconvinced that the altered pedagogies would improve learning. A major factor emerging from many studies is that of *time*; student-centred pedagogies were seen as more time-consuming, and teachers felt pressure to use direct instructional methods to ensure content coverage (Cosgrove et al., 2012; Irish Mathematics Teachers Association [IMTA], 2012; Johnson et al., 2019; O'Meara & Prendergast, 2018). The present study draws especially on the work of Johnson et al. (2019).

Research Questions

1. To what extent are the methods of instruction promoted by the aims and objectives of the PM curriculum used within the LC HL classroom?
2. What factors have most influence on the pedagogies used in the LC HL classroom?

Methodology

A web-based survey instrument was used to collect quantitative and qualitative data through closed and open questions, using the Qualtrics survey platform. The mixed-method approach was taken since the introduction of qualitative questions provided an opportunity to supply context and to allow for further explanation and enhancement of answers in the quantitative aspect of the survey (Bryman, 2012). The instrument consisted of 13 questions (11 closed and two open). Initial items addressed the level of teaching experience of respondents, both in general and specifically in relation to teaching the LC HL curriculum. The other items were of Likert type with five or more scale points. Respondents were asked to indicate their frequency of usage, in their LC HL classrooms, of each item in a list of pedagogies (see Table 1, below), chosen because they were advocated for PM or reportedly (still) used in classrooms. An option to add other pedagogies was provided. Respondents were also asked to rank their comfort level with each approach and their perception of its effectiveness. Two further, related, questions asked them to a) provide a rationale for their pedagogic choices (items such as "I use methods I have always used" or "I feel restricted and/or am afraid to try new methods"), and b) rank the influence of a list of factors on their choices (Table 2).

The survey was distributed in February 2020 to teachers of LC HL mathematics through professional networks, such as the Irish Mathematics Teachers Association (IMTA), and social media (Twitter), using voluntary and snowball sampling methods. The total of 111 responses was broadly in line with similar studies; the work by Johnson et al. (2019) received 147 responses. For the quantitative data, the software package SPSS was used to conduct descriptive and inferential analysis including Pearson's Correlation tests to identify potential relationships between variables. According to Norman (2010), tests such as Pearson's Correlation are robust enough to handle data from Likert-type items with five or more scale points. For qualitative responses, thematic analysis was used to identify key themes.

Limitations of the work should be noted. Survey items were designed in-house; despite piloting and discussion with colleagues, some element of bias may exist. While the wide reach of the IMTA may have helped to access participants across a range of experience and geographical locations, sampling did not use probabilistic methods, so the sample may not be representative (Bryman, 2012). Finally, data have the limitation of being self-reported.

Results

Analysis revealed that while the median level of teaching experience across all subjects was 11-15 years, the median number of years teaching LC HL mathematics was lower, at 6-10 years. However, teaching experience did not appear to influence other variables in the study.

Pedagogies Used and Influence on Choices

With regard to *pedagogical approaches* used, direct instruction remains predominant for the majority of the teachers; fewer than a quarter of teachers identified problem-solving, inquiry-based learning (IBL), group work or flipped approaches among their frequently-used

strategies (Table 1). The more teacher-led methodologies ranked higher in terms of comfort and perceived effectiveness. While causal links between perceived effectiveness and comfort cannot be inferred, it is noteworthy that three of the seven methods have the same median for comfort and for effectiveness, while only one method differs by more than one scale point.

Table 1

Percentage of Teachers (n=111) Most Frequently Using Listed Pedagogies, with Median Comfort and Effectiveness Scores

Pedagogy	% of teachers using frequently	Median comfort level	Median perceived effectiveness
Direct instruction (chalk and talk)	61	7	7
Open-ended questioning	34	5	5
Discussion and debate	26	5	4.5
Independent problem solving	24	4	4.5
Group work	23	4	3
Inquiry-based learning (IBL)	14	3	3
Flipped classroom	7	3	1

Note. 1 = least comfortable / effective; 7 = most comfortable / effective.

The factor most influencing the teachers' choice of approach is *time*, with one teacher explicitly remarking that "Time pressure affects methods used to teach." Indeed, further examination of respondents' perceptions in relation to time constraints revealed that 65% do not believe there is adequate time to complete the course, and only 19% consider their pace as one that "suits" the students. Teachers' comfort and experience, and the group being taught, are other factors receiving considerable endorsement (Table 2).

Table 2

Percentage of Teachers (n=111) Ranking Factors Influencing their Choice of Approach

Factor	% of teachers ranking top influence	Median ranking
Time constraints	39	5
Comfort and experience with method	26	4
The group of students in the class	25	5
Facilities and resources available in school	8	3
Whole-school approaches to teaching and learning	1	2
Best practice guidelines from NCCA, research, etc.	0	2

Note. 1 = least influential, 6 = most influential.

Correlation Analysis

Correlation analysis revealed some interesting potential relationships between the level of comfort, perceived effectiveness, influencing factors, and types of pedagogies used. There was a statistically significant positive relationship between the use of *direct instruction*

and the *level of comfort* with the method ($r = 0.437$, $n = 74$, $p = 0.03$). This connection was further illustrated by the positive relationship between a perception of being *restricted/afraid to try new methods* and *direct instruction* ($r = 0.244$, $n = 73$, $p = 0.04$). Qualitative statements indicating that teachers "cannot afford to waste time if experimental methods do not work," and that "on balance it simply isn't rewarded in the exam," support this connection. Exploration of factors positively associated with the student-centred approaches of *IBL* and *independent problem-solving* suggests the importance of a *whole-school approach to teaching and learning* ($r = 0.276$, $n = 67$, $p = 0.02$ and $r = 0.272$, $n = 67$, $p = 0.03$ respectively).

Discussion and Conclusion

This study aimed to identify the extent to which the methods of instruction promoted for the "Project Maths" curriculum are used in Leaving Certificate Higher level (LC HL) classrooms, and to identify factors associated with uptake of the different pedagogies. The results show that for the 111 teachers (not necessarily a representative sample) who responded to the purpose-designed survey, "direct instruction (chalk and talk)" – a method that was intended to be de-emphasised for Project Maths – is still the most frequently used pedagogy, with respondents being most comfortable in using it and most convinced of its effectiveness. Respondents were less comfortable in using the more "reform-type" methods promoted for Project Maths and also less convinced of their effectiveness. These findings are consistent with some ongoing resistance to methods still viewed, as stated by a respondent quoted above, as "experimental"; it also echoes an earlier point from the findings of TIMSS 1995, highlighting the importance of taking teachers' beliefs into account when trying to implement curriculum change. Factors reported as affecting choice of pedagogy are dominated by time constraints and to a lesser extent by comfort and familiarity, together with perceived relevance for the student group being taught. Perceptions that the high-stakes Leaving Certificate examination does not reward student-centred approaches are relevant also.

The results with regard to *frequently-used pedagogies* and *time* are similar to those from previous research (Johnson et al., 2019), in this case specifically for LC HL teaching. The qualitative data illustrate potential reasons why respondents may favour certain methods for the *group of students* that they are teaching. Specifically, there is a sense that the cohorts of students attempting LC HL are less academically strong than for previous HL curricula, given the allure of extra points: "Bonus 25 points encourages students who are not able for HL to hang on… ultimately increasing time constraints on teacher." One response provides a summary: "the system makes me teach the way I teach. Nothing significant will change until time, amount of content, or university selection processes change."

Kärkkäinen (2012) recognises that for teachers to engage fully with a reform; it is essential that they understand and agree with the reasoning behind it, its implications for their practice, and its consequences for their students. Findings reported above suggest that, if intentions for use of more active, student-led pedagogies are to be implemented, professional development addressing both rationale and hands-on practice is still required, for teachers across all ranges of experience. The need for even more professional development than accompanied the rollout of the Project Maths initiative was identified by Byrne et al. (2021).

Other points arise here. The present study does not address whether, or how, the "reform" pedagogies used in the Irish context actually lead to improvement with regard to the objectives of the reformed curricula and specifically each of the five strands of mathematical proficiency (Kilpatrick et al., 2001; NCCA, 2013). The work of Hiebert and Grouws (2007) indicates that effective teaching can occur with various forms of classroom organisation. Further work with regard to pedagogy might examine the effectiveness of different instructional methods in achieving mathematical proficiency through the present curriculum. Implications for eventual curriculum change include addressing the time factor – the major reported constraint to implementation of intentions – and the apparent mismatch between the pedagogies encouraged and those rewarded in the high-stakes examinations.

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