International Electronic Journal of Elementary Education, 2015, 8(2), 317-332.

Mathematics Curriculum in Ireland: The Influence of PISA on the Development of Project Maths

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Abstract

This article interrogates the extent to which the Organization for Economic Cooperation and Development (OECD) through its Programme for International Student Assessment (PISA) influenced the development of Project Maths, a new second-level mathematics education policy in Ireland. It argues that the Irish government, in its revision of mathematics education policy, was strongly influenced by PISA and that concern with the country's 'average' placement in the international assessment was instrumental in defining the direction of the revision. It traces the genetic imprint of PISA on the development of curriculum policy, the new mathematics syllabus, its content and assessment. It argues that Project Maths sets out to follow closely the PISA conceptual framework. However, the analysis finds that Project Maths is not a mini-PISA but that the programme is comprised of two distinct approaches, on the one hand retaining the abstract, symbolic mathematics of sections of the pre-existing curriculum, while on the other emphasizing a PISA-like approach to pedagogy and to real-life problem solving.

Keywords: Mathematics education, PISA, Project Maths, Policy development, Ireland

Introduction

The discourse of the reform of mathematics education takes place within the fields of education, politics and economics. Within this discourse educational change is framed as occurring within a rapidly changing economic environment which includes developing knowledge economies, technological advances and shifts in labour patterns. This changing context, it is argued, calls for radical changes in education. Mathematics, in particular, is mobilized in the rhetoric as the engine of innovation, the means to developing problem solving skills and independent thinking, the key to the success of knowledge economies. Within this discourse it is argued 'policy can no longer be "thought" or "thought about" within the limits of the nation state and national boundaries' (Ball, 2009, p. 537). Although national governments still retain their power to develop their own policies, education

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ISSN:1307-9298

www.iejee.com

policies in general tend to reflect a distinct set of values 'whose authority is allocated at the intersection of global, national and local processes' (Rizvi & Lingard, 2010, p. 3). One major influence in this 'internationalisation' of education policy is the Organisation for Economic Cooperation and Development (OECD) (Grek, 2009).

Since the late 1990s the OECD has positioned itself as an agent in national education policies through its development of comparative indicators and its generation of data for steering educational systems (Carvalho, 2012). In particular, through its development of the Programme for International Student Assessment (PISA) it has become a technology of government, a tool in the reform of education policy. PISA is a triennial international survey which aims to evaluate education systems worldwide by testing the knowledge and skills of 15 year-old students (OECD, 2015). The programme is formulated to produce policy-orientated and internationally comparable indicators of student achievement (OECD 1999a, 7) together with quantifiable measures of human capital (OECD 1999a, 11). It does this by testing the knowledge and skills of student populations at the end of compulsory schooling. The 'challenges of today's knowledge societies' (OECD, 2002, p. 9) underlie the OECD/PISA problematisation of education systems and in this respect PISA professes to examine 'the extent to which young people have acquired… knowledge and skills' (OECD, 1999b, p.11) and their ability to use them to meet real-life challenges. The OECD itself has carefully constructed these 'knowledge', 'skills' and 'competencies' under a programme begun in 1997 – The Definition and Selection of Competencies (DeSeCo) project. DeSeCo forms the theoretical underpinnings of OECD/PISA (DeSeCo Project, 2005, p.3; OECD, 2009, p.7). Through its assessment of OECD-defined skills and competencies (DeSeCo Project, 2005; OECD, 2001), and its prioritisation of OECD-defined 'literacies' in mathematics, science and reading (OECD, 1999a), PISA provides a 'legitimate' framework within which states can undertake education policy change. It is a powerful policy instrument (Grek, 2009; Ozga, 2012; Rizvi & Lingard, 2010) supplying data which contribute to a shift in the definition of knowledge under the influence of the knowledge society construct (Carvalho, 2012). It provides support for a move away from traditional school-based learning (Cosgrove, Shiel, Sofroniou, Zastrutzki, & Shortt, 2004). PISA's stratified league tables have the effect of reducing 'educational excellence to test scores' (Clarke, 2012, p. 301). Through its production of internationally agreed objectives, norms and standards it exerts a form of 'soft power' (Bieber & Martens, 2011, p. 101).

This paper examines the extent of the influence of OECD/PISA on the development of mathematics education policy in Ireland. The central questions are: to what extent has recent mathematics education policy at second-level been informed by OECD/PISA and in practical terms, does the new second-level mathematics curriculum, Project Maths, bear the genetic imprint of OECD/PISA and if so, to what extent?

Method

The research involves an analysis of documents relating to the development of Project Maths up to its national 'roll-out' to all schools in 2010. The mass of empirical data for this analysis will come from official government publications or government-commissioned publications, OECD reports, national and international reports, departmental papers, studies, strategic plans, review documents, mathematics syllabi etc. – that is, the set of documents and acknowledged texts which relate in any way, either partly or in full, to mathematics education policy, and to the reform of mathematics curricula at second-level in Ireland. The documents analyzed emanate from a diverse range of sources – local, national and global, the published acknowledged narrative. Michel Foucault uses the felicitous phrase 'a history of the present' (Foucault, 1977, p. 31) to describe this kind of undertaking. In his work it is an analysis of how things have come to be as they are.

The main body constitutes an analysis of the conceptual framework on which Project Maths is based. The framework for this analysis mirrors that of the OECD and considers the presence or otherwise, in Project Maths, of the three 'dimensions' of PISA which correspond to 'process skills, knowledge and understanding, and context of application' (OECD, 2002, p. 12). The concept of mathematics education present in Project Maths will be compared with PISA's concept of mathematical literacy.

Thus the article will consider the extent to which the new programme has been influenced by the philosophy underlying PISA, its approach to mathematical literacy and to its assessment.

Mathematics Education in Ireland

In Ireland the study of mathematics is mandatory at primary school. At secondary school all students study the subject in junior cycle (to approx. age 15), while at senior cycle upwards of 86%[1] of students study it and the vast majority of these take mathematics in the Leaving Certificate examination. Mathematics syllabi are developed and implemented centrally under the auspices of the National Council for Curriculum and Assessment (NCCA). At second-level the subject is examined nationally at the end of junior cycle and again at the end of senior cycle by means of two state examinations, the Junior Certificate and the Leaving Certificate. These are constructed, administered and corrected centrally by the State Examinations Commission (SEC).

In 2010 Project Maths, a radically new second-level programme of mathematics education, was introduced to all second-level schools in Ireland[2] (full implementation of the project would be completed in 2015). According to official sources the project 'involves empowering students to develop essential problem-solving skills for higher education and the workplace by engaging teenagers with mathematics set in interesting and real-world contexts' (NCCA, 2015). It replaces previous mathematics programmes[3] whose foundations lay in the 'New Maths' system introduced in the early 1960s (NCCA, 2002) where the curriculum involved formal 'comparatively abstract and symbolic mathematics' (Oldham, 1991, p. 127) and was 'characterized by emphasis on structure and rigour' (NCCA, 2002, p. 4).

Over the years mathematics education 'functioned in an inherently conservative rather than an inherently innovative manner' (Oldham, 2001, p. 275). Successive revisions attempted to 'fix' syllabus related problems rather than provide an opportunity to review courses thoroughly or to give consideration to an appropriate philosophy for mathematics in the new millennium (Shiel, Cosgrove, Sonfroniou, & Kelly, 2001). For example, the Junior Certificate syllabus revision carried out during the 1990s, which, as we will see, has been the subject of many official PISA-related reviews and criticisms, was the outcome of a process whose limited remit specified that 'the outcomes of the review would build on current syllabus provision and examination approaches rather than leading to a root and branch change of either' (NCCA, 2002, p. 6). However, the revised syllabus was accompanied by 'some changes in *emphasis*: or rather, in certain cases, for some of the intended emphases to be made more explicit and more clearly related to rationale, content, assessment, and … methodology' (NCCA, 2002, p. 17).

[1] Percentage based on figures for 2014 received from the State Examinations Commission
[2] The pilot phase of Project Maths was introduced to 24 schools in 2008.
[3] The pre-2010 Leaving Certificate syllabus was introduced in 1992 and the pre-2010 Junior Certificate syllabus was introduced in 2000

When the revision was introduced to schools in 2000 it was accompanied by an inservice programme for teachers which aimed to radically change how mathematics was taught, replacing traditional didactic methods of instruction with 'active learning methodologies' (NCCA, 2002, p. 25). This move, I contend, was in part a response to a benchmarking report produced by the Irish Council for Science, Technology and Innovation (ICSTI) (1999) – initiated on foot of Ireland's decision to position itself as a *knowledge economy* – which aimed to identify key issues in school science, technology and mathematics (STM) education that required attention. The report found that at post-primary level 'all countries are moving towards more emphasis on practical, student-centred, active-learning models' (Forfás/ICSTI, 1999, p. 22) and recommended a similar move in Ireland. Also at this time OECD/PISA had been instituted and there was an awareness among Irish policy agents of the 'very different philosophy' of Realistic Maths Education (RME) underpinning PISA which it was expected would 'highlight weaknesses' (Oldham, 2001, p. 276) in Irish mathematics education. Thus with the *knowledge economy* as catalyst, evidence of best practice from the benchmarking report, and OECD/PISA as a policy instrument the process of reform of mathematics education policy was undertaken.

An empirical bridge: PISA and the Educational Research Centre

The Educational Research Centre (ERC), on behalf of the Department of Education and Skills (DES), implements PISA in Ireland (Educational Research Centre, 2015); it fine-tunes and runs the assessment, grades it, provides commentary on it and is commissioned to prepare the official reports. It is supported in its work by a National Advisory Committee which includes members of the DES, the NCCA and 'subject matter experts' in mathematics, science and reading. Following each PISA assessment the ERC publishes a series of reports, which coincide with the publication of the OECD reports, and which provide statistical data and comment on the performance of Irish students. The ERC, as sub-contractor of the state, is never critical of the PISA process or its underlying assumptions. As mentioned earlier PISA aims to provide empirical evidence which will inform policy decisions and the ERC as an agent of the State is employed to provide the 'empirical bridge' between the PISA assessment and policy. We can trace the construction of this empirical bridge in relation to mathematics education policy in the PISA-related publications of the ERC, especially in the ERC's test curriculum rating and comparison exercises.

In the first assessment, PISA 2000, Ireland achieved a mean score of 502.9, not significantly different from the OECD country average, on the mathematical literacy scale and it ranked 15th of 27 countries (Shiel et al., 2001, p. 44). In its report, the ERC attributed the average performance in part to 'substantial differences between what students at Junior Cycle are taught and what PISA mathematics assesses' (Shiel et al., 2001, p. 158) and proposed, for further consideration, the question of whether the Junior Certificate should be assessing mathematical skills that are similar to the PISA mathematics assessment. The very act of pairing the two assessments, which take place at roughly the same stage of schooling (age 15 years), contributed to the construction of a new discourse; thus the average performance in PISA provided evidence that the Junior Certificate programme was in need of revision. Given the generally accepted view that assessment determines pedagogy and, to some extent, curriculum, a convergence of assessment could be expected to produce a convergence of classroom practice and syllabus too (Torrance, 2009).

In the second iteration, PISA 2003, Irish students again achieved a mean score which was not significantly different from the OECD country average and was ranked 20th among 40 OECD and partner countries (Cosgrove et al., 2004, p. 48). The lack of improvement was noted and attributed, in part, to the hypothesis that 'the impact of curricular change on students' achievements, if any, is likely to be slow' (Cosgrove et al., 2004, pp. 164-165) an analysis that implies that the ERC and its National Advisory Committee had expected some convergence between the assessment and the revised Junior Certificate curriculum of 2000. The ERC report included a PISA 2000 test-curriculum rating project which compared the 'intended' Junior Certificate Examination syllabus and PISA. It analysed the performance of students in PISA and examined 'the relative strengths and weaknesses displayed … in terms of what they might reasonably be expected to learn in school' (Cosgrove et al., 2004, p. 40). The report observed that a number of the objectives of the revised syllabus could be compared 'in a general way' with the PISA mathematics framework, a comparison which depicts the new syllabus as being 'somewhat similar to the PISA approach to mathematics' (Cosgrove et al., 2004, p. 163). Another move in the PISA direction observed in the report concerns the new teaching methodologies, which it says were an attempt to 'move away from mechanistic approaches towards teaching for understanding, a change that is consonant with the philosophy underlying PISA mathematics' (Cosgrove et al., 2004, p. 164). It is clear that the ERC had expected that the 2000 revision of the Junior Certificate would bring it somewhat closer to PISA.

However, by PISA 2006 there was again no improvement in the score[4] and while acknowledging the apparent lack of effect of the revised syllabus on the PISA scores a new aspiration was expressed 'that new developments, such as Project Maths, may be diverse enough in content and focus to raise the achievement of high performers in mathematics as well as catering to the needs of students at other performance levels' (Eivers et al., 2008, p. 138). Thus Project Maths became, for the ERC and its advisors, the apparent route to future success at PISA.

Let us now consider why the ERC may have put its trust in Project Maths and whether or not that trust was justified. The framework for this analysis will mirror that used by OECD/PISA in its analysis of mathematical literacy and its assessment.

Mathematical Literacy and Project Maths

In the late 1990s PISA's Expert Group for Mathematics proposed its definition of mathematical literacy an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded mathematical judgements and to engage in mathematics, in ways that meet the needs of that individual's current and future life as a constructive, concerned and reflective citizen. (OECD, 1999a, p. 41)

This definition focuses on the individual and her involvement with mathematics and how her engagement with mathematics is perceived to permeate all aspects of her life. Certain aspects of the definition have specific meaning in the PISA context. The term 'literacy', for example, indicates 'the ability to put mathematical knowledge and skill to functional use rather than just to master it within a school curriculum ….. the ability to pose and solve mathematical problems in a variety of contexts' (OECD, 2002, p. 82). According to de Lange, (chair of PISA's Expert Group for Mathematics which developed the definition of mathematical literacy), the definition addresses the goal of preparing students for society and for future schooling and work and is not concerned with showing students 'the beauty of the discipline' (de Lange, 2006, p. 21). In this respect Project Maths adopts the PISA model of mathematical literacy in all but name, aiming to introduce to the school curriculum mathematical knowledge and skill in a more applied format and

[4] Ireland's mean score was 501.5, which is not significantly different from the OECD country average. Ireland ranked 16th highest among OECD countries, and 22nd among 57 participating countries. (Eivers, Shiel, & Cunninghan, 2008, p. 60)

abandoning the philosophy which considered mathematics as 'the queen and the servant of the sciences' (Department of Education, 1992; DES, 2000). Project Maths is designed to ensure that current and future students of mathematics at post-primary level will have the opportunity to engage in their studies in a manner which will enhance their understanding of the subject, provide contexts and applications of mathematics that are meaningful and relevant, and enable them to develop problem-solving skills and strategies that will serve them not only in their future study of mathematics but also in their daily lives. (NCCA, 2008, p. 5)

The move replaces the formal, comparatively abstract and symbolic mathematics with a more practical approach to the subject. In the new programme mathematics is seen as the key to opportunity. No longer simply the language of science, mathematics contributes in direct and fundamental ways to business, finance, health and defence. For students it opens doors to careers….. For nations it provides knowledge to compete in a technological community. Participating fully in the world of the future involves tapping into the power of mathematics. (DES/NCCA, 2010, p. 6)

Project Maths, therefore, emphasises the utility of mathematics, the role it is seen to play in 'the development of the knowledge society and the culture of enterprise and innovation associated with it' (DES/NCCA, 2010, p. 6). De Lange identifies PISA's emphasis on the element of 'functionality' and, in discussing countries which take the outcomes of PISA seriously, he claims that 'they embrace the idea that the output of an educational process should include a certain amount of 'functionality', but it is up to the countries to decide how important this aspect is' (de Lange, 2006 n.p.). In Project Maths, it is argued, that much of what students learn in the new programme will be about putting mathematical knowledge and skill to functional use rather than the application of procedures in 'a purely mathematical and abstract context' (Cosgrove, Oldham, & Close, 2005, p. 210). At all levels it is envisaged that mathematics will be taught 'in contexts that allow learners to see connections within mathematics, between mathematics and other subjects, and between mathematics and its applications to real life' (DES/NCCA, 2010, p. 6) and thus mathematics teaching and learning is being directed away from the traditional method with its 'formal and abstraction-focused approach' (Conway & Sloane, 2005, p. 23) towards the more instrumental approach to the subject. While not slavishly following PISA it is a very similar approach.

Three dimensions of mathematical literacy

In order to transform the definition of mathematical literacy into an assessment, the PISA mathematics Expert Group identified three broad dimensions: *processes, content* and *context* (OECD, 2002, p. 82) and outlined the criteria for assessment in each dimension. In doing this it clarified its assessment priorities and provided a framework for policy development. Tracing the genetic imprint of PISA will therefore involve an interrogation of the Project Maths syllabus and assessment material and an analysis of the existence or otherwise of these 'dimensions' in the data.

Process

Processes or process skills which priorities 'students' abilities to analyze, reason and communicate ideas effectively by posing, formulating and solving mathematical problems' (OECD, 2002, p. 13) are given precedence in mathematical literacy. The skills involved include thinking, argumentation, modelling, problem posing and problem solving, representation, symbolic, technical, communication, and skills in using mathematical tools and aids. PISA does not assess these process skills individually but organizes them into three classes, each of which defines the type of thinking skill required: (i) reproduction, definitions and computations; (ii) connections and integration of problem solving; and (iii) mathematisation, mathematical thinking, generalization and insight (OECD, 2002, p. 83). These classes or 'competency clusters' are called *reproduction, connections* and *reflection* (OECD, 2002, p. 82) respectively. The question to address here is to what extent these competencies are present in Project Maths syllabi and state examinations and whether or not they appeared in the the pre-2010 syllabi and associated state examinations?

1. Process: Competency clusters in syllabus learning outcomes. Project Maths aims to teach mathematics 'in contexts that allow learners to see connections within mathematics, between mathematics and other subjects, and between mathematics and its applications to real life' (DES/NCCA, 2012b, p. 6). The new syllabi, in line with OECD recommendations, are formatted in terms of 'learning outcomes' (OECD, 1999b, p. 3) and replace the traditional input/content structure of previous syllabi. Each strand of study is delineated by a brief description of the topic to be studied together with details of what students should be able to do. An analysis of learning outcomes in syllabi issued in 2012 (for examination at Leaving Certificate in 2014 and at Junior Certificate in 2015) provides some insights into the influence of the PISA conceptual framework on the intended curriculum. The 2012 syllabi were chosen for the analysis as this is the first set of Project Maths syllabi to include all five strands of study.

In the context of PISA, learning outcomes which reflect the characteristics of the *reproduction* competency cluster (reproduction, computations and definitions), deal with 'knowledge of facts, representing, recognising equivalents, recalling mathematical objects and properties, performing routine procedures, applying standard algorithms and developing technical skills' (OECD, 2002, p. 84). These competencies appear in Junior and Leaving Certificate syllabi learning outcomes in the form of requirements to be able to: recall axioms; engage with the concept of a function, domain, co-domain and range; solve first degree equations in one or two variables; use and apply the rules for indices; construct a variety of geometric shapes; recognise that probability is a measure on a scale of 0–1 of how likely an event is to occur; use a calculator to calculate standard deviation; graph functions; perform constructions; perform arithmetic operations; factorise expressions; use trigonometry to calculate the area of a triangle; illustrate complex numbers on an Argand diagram; etc. (DES/NCCA, 2012a, 2012b).

The second competency cluster *connections* (brings together mathematical ideas and procedures to solve problems in familiar contexts), expects students to make 'connections between the different strands and domains in mathematics, and integrate information in order to solve simple problems…..the problems are often placed within a context, and engage students in mathematical decision making' (OECD, 2002, p. 84). Project Maths learning outcomes in this category include: solving problems involving conditional probability in a systematic way; applying knowledge and skills to solve problems in familiar contexts; exploring patterns; analyzing and transferring information into a mathematical form; solving problems involving right-angled triangles, trigonometric ratios, finding profit or loss, income tax and net pay, surface areas, curved surface areas, volume, etc. (DES/NCCA, 2012a, 2012b). However, the syllabus is structured according to a series of five individual strands (we will discuss this in more detail later) and consequently the making of connections between and across strands and different domains of mathematics is not prescribed by the learning outcomes. Nevertheless, elsewhere the syllabus states that 'where appropriate, connections should be made within and across strands and with other areas of learning' (DES/NCCA, 2012a, p. 10).

The third competency, *reflection* (involves mathematical thinking, generalization and insight, and requires students to engage in analysis, to identify the mathematical elements in a situation, and to pose their own problems), asks students 'to mathematise situations…to recognize and extract the mathematics…use mathematics to solve the problem, analyze, interpret, develop…models and strategies,…' (OECD, 2002, p. 84). Again this cluster occurs in the Project Maths syllabus learning outcomes, at both junior and senior cycles, in particular under the heading of 'synthesis and problem-solving skills' which is to be found in each strand of study. Within this section students are expected to learn to: explore patterns and formulate conjectures; explain findings; justify conclusions; communicate mathematics verbally and in written form; apply their knowledge and skills to solve problems in familiar and unfamiliar contexts; analyze information presented verbally and translate it into mathematical form; devise, select and use appropriate mathematical models, formulae or techniques to process information and to draw relevant conclusions (DES/NCCA, 2012a, 2012b). It is clear, therefore, that the PISA framework of competency clusters is present in the learning outcomes assigned to Project Maths and thus it can be considered part of the 'intended' curriculum. This adherence to the PISA competency clusters in learning outcomes translates into a two-part approach to assessment which involves a combination of old and new.

2. Process: Competency clusters and assessment. An analysis of Junior Certificate and Leaving Certificate Project Maths examination papers reveals a complex, almost schizoid, situation. In the examinations some syllabus items are examined within the context of real-life problems, while the examination of other items relies on the traditional abstract/symbolic question-type. This extraordinary situation, is I contend, linked to the inclusion of PISA and non-PISA items in the syllabi. Almost all PISA items are present in Project Maths and several curricular content areas of the pre-2010 syllabi (not assessed by PISA) have also been retained in the programme: equations, functions, sets, both formal and co-ordinate geometry, trigonometry and property of number (Merriman, Shiel, Cosgrove, & Perkins, 2014, p. 75). An inspection of post 2014 examination papers reveals that questions relating to the non-PISA items tend to retain the abstract nature of pre-2010 examinations while the assessment of PISA-type items reflects a more PISA-like approach to assessment. In the Junior Certificate higher level examination papers of 2015, for example, the non-PISA items account for approximately 45% of the recommended time allotment and are examined in a series of non-contextualized questions.

Table 1. Results of an analysis of question types from the 2015 Leaving Certificate and Junior Certificate examinations

Examination	Examination Level	Abstract/Symbolic %	'Real-Life' Problems %
Junior Certificate	Higher	45	55
	Ordinary	48	52
	Foundation	45	55
Leaving Certificate	Higher	48	52
	Ordinary	39	61
	Foundation	3	97

Table 1 presents the results of an analysis of question types from the 2015 Leaving Certificate and Junior Certificate examinations.

The figures (Table 1) clearly indicate the divide between the traditional abstract/symbolic approach to examination questions and the real-life problem-solving approach. With the exception of Leaving Certificate Foundation level, which is intended for students who may have a limited acquaintance with abstract mathematics (DES/NCCA, 2012b), there is a near 50/50 division between the examination of mathematics in an abstract form and real-life mathematics. It is difficult to imagine how the pedagogy of active methodologies introduced with Project Maths will transfer to the classroom within the context of this near 50/50 division. As mentioned earlier assessment tends to determine what is taught.

In the early 2000s such was the interest in PISA mathematics that a PISA/Junior Certificate assessment mapping exercise was carried out by two Irish mathematics education scholars (Close & Oldham, 2005). The findings of this research identified mismatches between skills examined by the Junior Certificate examination and those of the PISA assessment. The research arose out of the mathematical performance in PISA 2003 of Irish 15-year-olds as this had occasioned discussion about the contrast between the type of questions in PISA and those of the Junior Certificate examination. The authors – Close, drawing on his experiences as a member of the Mathematics Expert Group for PISA and Oldham, drawing on her experience as former Education Officer with the NCCA and a member of the PISA Mathematics Forum (Close & Oldham, 2005, p. 186) took questions from the Junior Certificate paper of 2003 and mapped these onto the PISA mathematics framework. The results were compared and contrasted. Considering that the Junior Certificate examination had its foundations in New Maths and the underlying philosophy of PISA is RME, it is not surprising that the analysis identified many 'mismatches' between the two assessments. In particular the Junior Certificate examinations contained no items on *reflection*, very few on *connections* and over 90% on *reproduction* (Close & Oldham, 2005, p. 196). Thus, according to this analysis, the process of mathematicisation, mathematical thinking, generalization and insight involved in the *reflection* competency cluster was absent from the examination and the making of connections between the different strands and domains in mathematics and the integration of information while solving simple problems as required in the *connections* cluster was poorly represented.

An analysis of the 2015 Junior Certificate examination papers reveals a PISA-like trend in many questions, although the traditional comparatively abstract and symbolic nature of previous examination questions is still in evidence. As mentioned above, the approach to the assessment of PISA and non-PISA items differs and consequently the skills examined vary according to the type of question presented. Questions relating to non-PISA items focus largely on performing calculations, solving equations and solving routine problems and belong, for the most part, to the *reproduction* cluster. The real-life problems require students to solve problems using familiar procedures in contexts, to recognise and extract the mathematics in problem situations, to reflect on and analyse situations etc. and in this way the *connection*s and *reflection* clusters are assessed. All three competency clusters are well represented in the assessment.

In relation to the pre-2010 Leaving Certificate examinations, an analysis of the 1999 higher-level and ordinary-level papers, for example, reveals the absence of the *reflection* competency and very few items on *connections*, while the majority of items fall into the *reproduction* category. At the higher level, apart from probability, questions were presented in an abstract format, while at ordinary level, some real-life problems were posed in relation to money, probability, statistics and linear programming, otherwise the examination dealt with abstract, symbolic mathematics. This situation was repeated with minor variations in all papers until the introduction of Project Maths.

In an effort to aid the implementation of the intended curriculum, in advance of the first Project Maths Leaving Certificate examination for the pilot schools, the SEC issued a set of Leaving Certificate sample papers for phase1 of the project together with a set of proposed solutions. It subsequently published a report on this trial assessment. The process was intended to measure the effectiveness of the draft sample papers and the marking schemes but the outcomes of the trialing were also to 'assist with the implementation of the syllabus itself…[and]…to clarify the objectives and learning outcomes of the syllabus for teachers, candidates and other interested parties' (SEC, 2010, p. 8). According to the SEC it is the combination of examination paper and marking scheme 'that determines what competencies are measured and in what proportion' (SEC, 2010, p. 105). Thus the examination determines what is taught. This is somewhat ironic considering that teaching to the test was a frequent complaint regarding earlier syllabi (NCCA, 2005).

On reading the SEC report (SEC, 2010), the language and underlying skills philosophy of PISA is evident. Each suggested solution is preceded by a statement of the main assessment objective(s) whether it is to 'demonstrate understanding of concepts and connections' or to 'execute routine procedures in a mathematical context', or to 'apply understanding within a mathematical context' or to 'demonstrate understanding of concepts, connections, conditions and implications', the objective is clearly defined.

In the trial examination papers the *reproduction* cluster presents itself through assessment objectives such as: execute routine procedures in a mathematical context; demonstrate knowledge of notation and terminology; apply routine procedures; demonstrate use of geometrical instruments; demonstrate knowledge of terminology and facts (SEC, 2010). Assessment of the *connections* cluster is to be found in questions that require the student to: apply routine procedures (in non-mathematical context); in a non-mathematical context, apply routine procedures (viz. execute trigonometric calculations); in a non-mathematical context, apply routine procedures, interpreting the solutions in the original context; (SEC, 2010). And the *reflection* cluster, which was absent from the previous syllabi, is very much in evidence in questions which require students to: in a mathematical context, apply understanding of concepts and connections, including relevant conditions, implications; demonstrate understanding of concepts, connections, conditions and implications; in a non-mathematical context, apply understanding of concepts and connections, interpreting solutions, conditions and implications in the original context (viz. 'mathematise' the presented problem and show how to solve it) (SEC, 2010).

It seems likely that these competency clusters were deliberately designed to mirror the PISA. However by 2015 the divide between the traditional and the new had crystallised. When all five strands of the project were examined 56% of the Leaving Certificate higher and ordinary level papers were focused on real-life problems and the remaining 44% of the items examined were situated within the traditional abstract question format. All competency clusters *reproduction, connections* and *reflection* were duly represented.

At both Leaving Certificate and Junior Certificate levels PISA-related material was examined in a PISA-friendly style while material that does not appear on the PISA assessment was examined by traditional abstract/symbolic questions. Far from being a radical shift, the examination looks like a compromise.

Content

It is in the area of syllabus content that Project Maths distinguishes itself from PISA. As we have seen Project Maths has been influenced by the concept of mathematical literacy and it has incorporated the PISA defined competency clusters in its learning outcomes and assessment objectives. Under the influence of PISA the intended curriculum has given priority to interpreting and solving mathematics problems embedded in realistic contexts and this in turn has affected the teaching and learning process where teaching via problems is advocated (Project Maths website, 2011). But the two programmes diverge in their approach to content.

The Project Maths syllabus classifies the mathematics curriculum in five separate content strands. The 2008 pilot phase and the 2010 national roll out of the project involved a phased introduction of these syllabus strands at both junior cycle and senior cycle and it is reasonable to conclude that the decision to opt for strands was at least partly administrative allowing for the introduction of relatively discrete areas of study over time. The five strands are: statistics and probability; geometry and trigonometry; number; algebra; functions (NCCA, 2008, p. 2). The practice of classifying mathematics curriculum in content strands is rejected by PISA on the grounds that it compartmentalizes mathematics and does not allow for the complexity of problems, nor does it reflect the complex patterns of the world around us (OECD, 2002, p. 84). De Lang argues that it encourages students to view mathematics as a 'collection of fragmented pieces of factual knowledge' (de Lange, 2006, p. 7). The mathematical content of PISA itself is organized around a phenomenological approach, 'describing content in relation to a phenomenon and the kinds of problems for which it was created' (OECD, 2002, p. 84). The phenomena are referred to as 'overarching concepts' and they were selected in order to 'encompass sufficient variety and depth to reveal the essentials of mathematics and… at the same time represent or include the conventional mathematical curricular strands'. The PISA 'overarching concepts' are: change and relationships, space and shape, quantity and uncertainty (OECD, 2002, p. 84).

The Project Maths adoption of the content strand structure at second level was intended to provide a link between the primary and secondary school curriculum (NCCA, 2008) along the 'pathways' which the different topics of mathematics follow as the learner progresses from primary to secondary school (DES/NCCA, 2011, p. 8). This approach reinforces the compartmentalizing of the subject in spite of assurances by the Project Maths development team that 'the various strands of mathematics are inter-related, and therefore can be taught in a more integrated manner' (NCCA, 2008, p. 2). However, the ideal of an integrated approach to the subject succumbs to practicality and the authors of the trial report attempted to justify the proposed sequential introduction of the Project Maths strands (SEC, 2010) being presented as 'stand-alone component[s] of the course' (Grannell, Barry, Cronin, Holland, & Hurley, 2011, p. 5). The decision to introduce strands in a 'stand-alone' manner was influenced by factors such as 'the need to balance an increase in syllabus elements in one strand with a decrease elsewhere, and confining the impact of change at the examinations to one paper in any given year' (NCCA, 2008, p. 2). The effect of the mode of introduction and of the subsequent examination limited the extent of inter-relation in the assessment and hence in the classroom.

In spite of the difference in approach to content only a small number of PISA items are not covered by the Project Maths curriculum, these include 2-D and 3-D rotations of objects and it is argued that Project Maths students might not be familiar with relating information on a table to information on a map or chart (Merriman et al., 2014). As mentioned above, both junior and senior cycle syllabi retain a number of non-PISA items: equations, functions, sets, both formal and co-ordinate geometry, trigonometry and property of numbers (Merriman et al., 2014, p. 75). Pre-2010 junior cycle syllabi did not include the study of probability, at that time this content was reserved for senior cycle. New syllabi, at all levels, emphasize probability and a DES statement relating to Project Maths stated that 'the changes other than in probability and statistics are methodological rather than content based' (DES, 2010) although subsequent criticism of Project Maths would disagree with this statement (Grannell et al., 2011; Stack & Other Maths Professionals, 2012).

Context

The third dimension of PISA mathematical literacy deals with the context within which mathematics is applied. PISA tasks are designed to include a variety of situations such as 'personal life, work and leisure, the local community, and society' (OECD, 2002, p. 82). Project Maths, on the other hand, seeks to teach mathematics in contexts that will allow learners to see connections between mathematics and its applications to real life. In the Project Maths programme these context areas are reflected in lesson plans, sample questions and in state examination questions. Many problems are set within 'realistic' situations which involve personal taxes, mobile phone choice, swimming pools, water towers, golf courses, oil spills, password combinations, student heights, health etc. It is difficult to assess how authentic the chosen contexts can be however. While discussing the (un)realistic nature of a particular question from the 2010 Leaving Certificate examination paper, for example, the University College Cork (UCC) interim report on Project Maths remarked that '"[r]eal-world" problems should be formulated so that they are not silly' (Grannell et al., 2011, p. 29). Many of the so-called 'real-world' problems are outside of the experiences of students and thus the interpretation of questions can cause greater problems than the mathematics required for the solution. Questions relating to 'negative equity' or to the 'tolerance of batteries' (Leaving Certificate 2012), for example, may be just as confusing for some students as a 2012 Leaving Certificate question based on a 'robotic arm' which was considered biased towards those who study Physics or Applied Maths and which became the subject of a parliamentary question in autumn 2012 (O'Connor, 2012).

Another aspect of 'real-world' problems is their literacy demands and in this respect, it is argued that, the 'presentation of information in the Project Maths syllabus is more like PISA than in the pre-2010 syllabus' (Merriman et al., 2014, p. 75). Both PISA and Project Maths are criticised for the high level of literacy required by students to successfully engage with 'real-world' problems (Eivers, 2010; Merriman et al., 2014). Eivers argues that setting problems in context hampers the validity of the assessment and that for many students their 'reading skills have an unnecessarily large effect on how well (or poorly) they perform on … mathematics assessments' (Eivers, 2010, p. 100). The problem for Project Maths, is highlighted in the case of students with reading difficulties or possibly those for whom English or Irish are additional languages. In this context in 2012 the national secretary of the Irish Mathematics Teachers Association (IMTA) was critical of the level of difficulty of the language used in a number of Leaving Certificate questions (O'Sullivan, 2012).

All of this is despite the fundamental category error of assigning a term like 'realistic' to an entirely artificial construct which is only found in the 'real' world in its singular form – namely, the paper and pencil, timed examination in an invigilated examination hall. In literature this kind of artificial construct of 'realism' is generally known as 'the realistic convention', and in terms of these word-based problems, the term is apt.

Conclusion

This article has argued that the Irish government in its revision of mathematics education policy was strongly influenced by the conceptual framework of PISA and that concern with the countries 'average' placement in the international assessment was instrumental in defining the direction of the revision. It has traced the influence of the PISA concept of mathematical literacy and its instrumental view of mathematics on the Project Maths rationale. It has shown that the aim of Project Maths to teach mathematics in contexts that allow students to see connections within mathematics, between mathematics and other subjects, and between mathematics and its application to real life facilitated the development of the curriculum within the conceptual framework of PISA. It has traced the inclusion of the PISA *competency clusters* in both the syllabus learning outcomes and in assessment. The emphasis on problem-solving within real-life contexts is a common feature of both PISA and Project Maths. Thus it is argued that Project Maths does bear the genetic imprint PISA.

However Project Maths is not a mini-PISA and the two programmes diverge in their approach to content and in their commitment to formal, abstract mathematics. In particular Project Maths retains the strand/topic structure in the area of content while the assessment of Project Maths reveals the existence of a curriculum focused in part on a traditional approach to abstract, symbolic mathematics, while at the same time prioritising the interpretation and solving of mathematics problems embedded in realistic contexts. In terms of pedagogy, teaching via problems is advocated by the DES despite the fact that almost half of the time/marks allocation on the assessment is for traditional abstract mathematics which teachers have long taught by didactic methods rather than active ones.

It is beyond the scope of this paper to speculate on how this will be reflected at classroom level or in future PISA assessments, but suffice it to say that in terms of mathematics education philosophy the compromise is problematical. Project Maths, according to the Minister for Education and Science, 'will promote greater maths literacy across the school population, bringing changed emphasis in the maths learned and, in particular, a strong focus on context, application and problem-solving in a general move towards a strengthened emphasis on real-life maths education' (Project Maths, 2010). It is notable that the Minister here talks about 'a strengthened emphasis on' rather than a switch to 'real-life mathematics'. It could well be argued that this 'strengthened emphasis', while not in evidence in curriculum and intended pedagogy is very evident in the assessment. The extent to which the assessment will ultimately govern the pedagogy will be interesting.

It remains to be seen whether this experiment in matching a national curriculum and pedagogy to an international assessment will have the desired outcomes of improving the country's position on the PISA league tables and producing suitably trained human capital which will satisfy the perceived needs of the knowledge economy. However the intensity with which the change was prosecuted by the Department of Education and Skills, and the clarity of its vision with regard to PISA, suggests that government believes there is a great deal at stake.

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