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The Perceptions of Irish Mathematics Teachers Toward a Curriculum Reform 5 Years After Its Implementation

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In Ireland the discussion about the educational goals of a curriculum have often been subsumed by the headlong rush to meet targets defined by state examinations, with the unfortunate consequence that the state examinations have often come to define the goals of the curriculum. In 2010 a new nationwide post-primary mathematics curriculum, locally titled "Project Maths," was introduced in an attempt to modernize a perceived out-dated curriculum by simultaneously altering the content of the curriculum, the pedagogical approaches employed by teachers, and the national assessment strategies. There was the belief by policy makers that only by altering all three of these curricular pillars concurrently could they definitively remove the prevailing approach of "teaching to the test." This study aims to investigate teachers' perceptions toward the implementation of this new curriculum 5 years after it was rolled out. A cross-sectional, mixed-methods research approach, that collected both qualitative and quantitative data, was employed via a nationwide survey of current mathematics teachers. Responses from 147 teachers indicated that for the most part teachers are supportive of the new curriculum goals, but that they are still struggling regarding the implementation of the intended curriculum in the classroom.

Keywords: curriculum reform, mathematics teachers, perceptions, continuing professional development, concerns

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INTRODUCTION

Over the past two decades there have been numerous calls to alter curricula and for teachers to focus more on the conceptual meaning underpinning the mathematics that they teach students rather than relying solely on practicing procedures and skills in the classroom (Ma, 1999; NCTM, 2000; Hiebert, 2013). Whilst for a long time conceptual and procedural knowledge were often viewed as two disjoint types of knowledge, current research now advocates that procedural and conceptual knowledge are not isolated concepts but develop interactively with "increases in one type of knowledge leading to increases in the other type of knowledge, which trigger new increases in the first" (Rittle-Johnson et al., 2001, p. 346). Although these calls for change are necessary to improve the overall teaching and learning of mathematics, they often result in countries altering their curriculum to such a degree that teachers ultimately feel hesitant and uncertain about how to enact and implement the new curriculum as instructed (Cuban, 1993; Fetters et al., 2002; Handal and Herrington, 2003; Lubienski, 2011; Guerrero, 2014). This uncertainty can have implications as teachers can be slow to implement the new curriculum and when implemented it is in a superficial

manner that does not alter teachers' fundamental beliefs about what it means to teach, learn, and do mathematics (Handal and Herrington, 2003).

In recent times the rationale behind altering the mathematics curriculum in many countries has been to develop more learner-autonomy where students are empowered to communicate their mathematical thinking whilst developing the skills to solve mathematical problems in different contexts (Doorman et al., 2007; Reiss and Törner, 2007; da Ponte, 2012). Doorman et al. (2007) stated that in the Netherlands they have altered their curriculum to be a more problem-oriented one based on the principles of realistic mathematics education. In Germany problem solving is specifically addressed as a process-oriented standard that should be included in the mathematics classroom across all grades (Reiss and Törner, 2007) whereas in Portugal da Ponte (2012) states that their new curriculum aims "to promote mathematics learning and the ability to use mathematics in different contexts" (p. 318). The promotion of these types of abilities are important, as according to Pegg (2010) higher order thinking skills only develop when students demonstrate the ability to use knowledge in related, but unfamiliar circumstances. Pegg (2010) defined higher order thinking skills as those skills located in the upper levels of Bloom's Taxonomy and involve application (using knowledge), analysis, synthesis and evaluation. Pegg (2010, p. 36–37) stated that students who develop higher order thinking skills "are able to: demonstrate some flexibility in their work; undertake problems without relying on step-by-step learnt algorithms; see novel connections not previously taught; have an overview of the concept under consideration and how different aspects of the concept are linked; show insight—able to undertake 'new' questions; and provide reasonable evidence of understanding." Over the last 30 years in the U.S. there have been numerous revisions and changes to the mathematics curriculum across different states with most recently the widely adopted Common Core State Standards in Mathematics, published in 2010, advocating a return to a problem-solving classroom with increased emphasis on placing mathematics in context (Schoenfeld, 2014a). This emphasis on problem solving and the applicable nature of mathematics is also a key element of many other international curricula, including the new "Project Maths" curriculum introduced in Ireland in 2010 (Lubienski, 2011). In tandem with changes to content these modern curricula also seek to alter the methodologies employed within the classroom by teachers in a bid to engage students more in active learning and tasks where sense making and justifying their reasoning are key components (Boaler, 2000; James and Pollard, 2008; Schoenfeld, 2014b).

A review of the Common Core State Standards for Mathematics in the U.S., up to level K-8, was conducted by Bay-Williams (2016) and found that approximately 90% of the teachers surveyed were following the topics outlined in the standards document. These teachers highlighted that they were paying more attention to the instruction of applications of mathematics within their teaching but a large minority of them (42%) did state that they still felt there was a misalignment between the mathematical materials available to them and what the standards required. Overall, Bay-Williams (2016) found that these teachers were changing their instructional approaches to align more with the standards but that there still was some confusion among the teachers regarding how exactly to implement the standards in some topics. Ultimately, the success of any curriculum reform is dependent on teachers, as they are a key central component of any curriculum reform (Datnow, 2002). Therefore, it is imperative that teachers feel involved, empowered, and informed with regards to the reform as their knowledge, perceptions, and attitudes toward the reform will influence how they interact with, and implement, it in the classroom (Charalambous and Philippou, 2010).

FACTORS AFFECTING CURRICULUM REFORM

Curriculum reform is a very complex process with many inhibitors and barriers to its success (Fullan, 2003; Handal and Herrington, 2003; März and Kelchtermans, 2013). Oftentimes policy makers and curriculum designers assume that the implementation of a revised curriculum will be a straightforward endeavor but in reality this is rarely the case (Orafi and Borg, 2009). Teachers seldom implement a curriculum in its intended form but instead alter and adjust it to fit with their pedagogical beliefs and existing teaching methodologies. This inconsistency between the *intended* and the *implemented* curriculum adds further to the challenge of enacting meaningful change when implementing curriculum reform (Cuban, 1993). The intended curriculum is the one outlined by the policy makers whereas the implemented curriculum is the actual one that the teachers apply in the classroom. There are many factors that affect how effectively a new curriculum is engaged with and implemented by teachers. Memon (1997) suggested a comprehensive list of these factors as can be seen in **Table 1**. The factors listed in **Table 1** are presented as inhibitors of curriculum reform but considering the "opposite" of each of these factors will provide a list of potential enablers of curriculum reform. The factors presented in Memon (1997) can be viewed as curricular, instructional, and organizational factors. Although this list is not exhaustive it outlines some of the major factors that influence the successful implementation of curriculum reform.

THE IMPORTANCE OF TEACHERS' BELIEFS AND CONCERNS

It has long been known that teachers' beliefs and perceptions about teaching and learning influence their practice in the classroom (Ernest, 1989; Thompson, 1992; Fang, 1996; Stipek et al., 2001). Teachers' beliefs are a key factor that shape their autonomy in the classroom, and thus have a significant impact on any initiative or reform that aims to alter the way they teach (Ernest, 1989). In fact, Handal (2003, p. 47) stated, "these beliefs appear to be cogent enough to either facilitate or slow down educational reform." Memon (1997) also listed the mismatch between teachers' beliefs and the curriculum goals as a key factor affecting the successful implementation of any curriculum reform. The literature on educational innovation has identified

TABLE 1 | Factors affecting educational reform in mathematics education (Memon, 1997).

Curricular factors	Instructional factors	Organizational factors
Externally imposed innovation	Importance attached by teachers to old practice	Lack of supportive mechanism
Change is not responsive to curriculum users' needs	Inadequate knowledge of subject matter, method and student assessment	Lack of coordination
Non-clarity of curriculum changes	Examination dominated teaching	Lack of communication
Mismatch between official curriculum and actual curriculum	Mismatch between teachers' belief system and curriculum goals	Lack of classroom materials
Imported innovation	Lack of detailed planning	Lack of physical facilities
Lack of curriculum users' participation	Lack of motivation, incentives and rewards	Lack of resources
Unplanned change	Lack of professional development	Lack of in-service training days
	Lack of classroom interaction	Lack of community participation
	Lack of students' interest	Influences of political leaders
		Influence of bureaucracy

frequent mismatches between curricular goals and teachers' beliefs as a barrier to the implementation of change (Orafi and Borg, 2009). Unfortunately, even if teachers' beliefs align with the curriculum goals it is not always possible to enact those beliefs due to the underlying nature of the educational system (Handal, 2003). In some instances the perceived school view regarding the importance of the subject can act as an impediment to the successful implementation of the curriculum (Liddicoat and Scarino, 2009), whereas other factors like timetabling (Fink and Stoll, 2005), and lack of leadership and coordination (Gleeson et al., 2002) can also hinder the implementation of the reform.

In terms of concerns, Fuller (1969) proposed one of the earliest models focusing on teachers' concerns regarding curriculum reform. This model was a hierarchical model made up of three levels: self-concerns, task concerns, and impact concerns. *Self-concerns* relate to teachers' anxiety about their ability to successfully engage with the new demands of the reform. *Task concerns* relate to concerns focused on the day-to-day duties associated with teaching e.g., covering the curriculum, lack of available resources, time constraints etc. *Impact concerns* deal with the consequences of the change to student learning. In the early stages of a reform teachers typically express intense self-concerns that over time diminish to be replaced by task concerns. Once the reform becomes more established teachers' concerns tend to evolve again and become more focused on its impact on students with many teachers eventually even suggesting alterations to improve its effectiveness (McKinney et al., 1999; Van Den Berg and Ros, 1999). Tunks and Weller (2009) substantiated the importance of this evolution in teachers' concerns through the three levels but stressed that only when teachers are continuously and substantially supported in implementing the reform will this shift occur.

THE "PROJECT MATHS" CURRICULUM IN IRELAND

Despite the significant reforms that were taking place internationally, the post-primary[1] mathematics curriculum in Ireland remained largely unchanged since the 1960's (National Council for Curriculum and Assessment, 2005). This syllabus focused predominantly on emphasizing mathematical structures, abstraction and rigorous presentation (Lyons et al., 2003). In 2005, promoted by the findings of many reports (e.g., Lyons et al., 2003; Smyth et al., 2004), which found that the nature of teaching in most mathematics classrooms in Ireland was still highly traditional and teacher-centered, the NCCA initiated a review of post-primary mathematics in Ireland. Research conducted as part of this review found that there was internationally a move toward a more real-world mathematics focus with an emphasis on the development of problem-solving skills (Conway and Sloane, 2005). Additionally, this research highlighted how countries that were highly ranked in international assessments emphasized the importance of the link between procedural skills and conceptual knowledge in their curricula (Conway and Sloane, 2005).

Following these publications the NCCA held discussions with a number of focus groups, including parents' representative groups and the council of the Irish Mathematics Teachers' Association (IMTA), the national association representing and supporting mathematics teachers in post-primary level schools in Ireland. Informed by the commissioned research and the consultation, and following consideration of a number of possible approaches, the NCCA proposed a new curriculum titled "Project Maths" in 2007.

Specialist mathematics committees were convened to advance syllabus and assessment revision under the Project Maths initiative. These committees comprised representatives of post-primary teachers, school management bodies and higher education institutions, as well as government bodies. The NCCA aimed to place teachers at the center of the curriculum development process and, in order to adapt the developments in light of feedback from the classroom, the new curriculum was initially rolled out in 2008 in a small number of pilot schools ($n = 24$), where changes in the syllabus and examination were phased in. The national rollout of Project Maths commenced in 2010 with changes to the five different strands of the curriculum (Number, Algebra, Geometry and Trigonometry, Statistics and Probability, and Functions) happening on a phased basis over the next 3 years.

[1]Most children commence post-primary education in Ireland when they are between 12 and 13 years old. Post-primary education typically lasts for 5–6 years.

The ethos of Project Maths was to move away from teacher-centered teaching methodologies that were recognized as being the norm in Irish post-primary mathematics classrooms pre-Project Maths (Lyons et al., 2003; Gill, 2006), toward more constructivist, student-centered, active learning methodologies. This shift in teaching methodologies was a fundamental aim of the curriculum reform and was explicitly stated within the curriculum documentation. Project Maths placed as equal an emphasis on the changing of teaching and learning practices as it did on the changing of syllabus content. Additionally, examination papers prior to the introduction of the new syllabus remained largely unchanged from year to year and hence displayed high levels of predictability. Options existed within the examination papers and as a result whole sections of the syllabus could be, and often were, omitted entirely by teachers and students. This resulted in a "teaching to the test" approach being adopted by many teachers, where strategies to succeed in examinations and an emphasis on procedural understanding at the expense of conceptual understanding were widespread (Gill, 2006; O'Meara et al., 2017). The summative assessment within the new syllabus attempted to address this issue by removing any options and additionally placing more focus on contexts and applications of mathematics than was previously the case. In terms of content, group theory and linear algebra were removed from the syllabus entirely, coinciding with a pronounced increase in the statistics and probability content. The amount of calculus content on the new syllabus was also reduced. The rationale behind these decisions was that if content levels were reduced teachers would have more time to execute the active learning methodologies prescribed within the new syllabus.

To support teachers in their efforts to implement the new curriculum a programme of professional development involving 10 full-day workshops over 5 years, with the focus on methodology, were organized and commenced in 2010. In addition to this, in response to requests from teachers for additional support in content knowledge, these workshops were complemented by a range of optional evening courses, facilitated by trained teachers, which dealt mainly with mathematical content topics and/or with issues regarding the use of ICT in the teaching and learning of mathematics. Additionally a week long summer course was run each year for a period of 3 years by the National Center for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL), based at the University of Limerick, to support teachers in the pilot schools during the initial phase of the curriculum reform. The materials developed for these workshops were made available to all post-primary mathematics teachers in 2010 once the curriculum was rolled out on a national scale.

The aim of this paper is to report on the perceptions of post-primary mathematics teachers in Ireland 5 years after the implementation of this nationwide mathematics curriculum reform. This curriculum reform sought input from teachers during the design phase of the curriculum and also offered substantial support to teachers during the 5 years following the rollout of the reform. From the literature review it is clear that there are many factors that affect the successful implementation of a curriculum reform. Memon (1997) highlighted how a mismatch between teachers' belief systems and the curriculum goals could impede the successful implementation of a curriculum. Therefore, this research sought to ascertain teachers' current levels of support for the new curriculum and also to identify potential barriers to the enactment of the curriculum, from the viewpoint of the teachers, 5 years after its introduction. The research questions guiding this study are:

1. What level of agreement do teachers display toward the ethos and goals of a new mathematics curriculum 5 years after its rollout?
2. What do teachers perceive as the main factors that are affecting their ability to successfully implement the new curriculum?

METHODOLOGY

The data presented in this paper are part of a larger research study that sought to determine what U.S., Irish, and U.K. mathematics teachers perceived to be the most important skills necessary to successfully engage post-primary students in mathematics (Freemyer et al., 2015). The ultimate goal of this larger project is to identify what *good* teachers do to encourage students to choose careers in Science, Technology, Engineering, and Mathematics (STEM) and communicate these approaches to other teachers. It is hoped that this research would allow U.S., Irish and U.K. mathematics teachers to learn from each other and thus improve the overall recruitment of students into STEM subject disciplines.

A sub-element of the larger research project, which focused on the perceptions of Irish mathematics teachers to a newly implemented mathematics curriculum, is presented in this paper. The research utilized a cross-sectional research design that sought information from numerous teachers at a single point in time (Bryman, 2008). Prior to design of the research instrument, interviews were conducted with 11 Irish university mathematics educators, 15 post-primary mathematics teachers, and the national director in charge of Project Maths. Observations of the 15 post-primary mathematics teachers were also conducted. The interviews and observations were used as a foundation for the creation of a nationwide survey to explore teachers' perceptions regarding the new curriculum and to ascertain how it has influenced the teaching and learning of mathematics at post-primary level in Ireland.

Survey questions emerged from themes noted from interviews of mathematics teachers, mathematics education professors, a Project Maths development officer, two previous researchers from the United States who conducted research on Project Maths, and a review of related literature on the topic. A positivist epistemological approach was taken for this research as it was deemed important to remain detached from the participants so as to maintain emotional neutrality, which is important when attempting to make clear distinctions between reason and feeling (Carson et al., 2001). In an effort to diminish the possibility of research bias, two Irish university lecturers and the president of the IMTA vetted the wording of the questions. The survey consisted of 10 Likert-type questions (see **Table 4** for the full list of questions), four multiple-choice questions, two open-ended response questions and a series of demographic questions

to determine information such as how long the respondents have been teaching mathematics. The Likert-type questions were employed to ascertain teachers' level of agreement with the goals of the reform and also to find out how effective they felt the new methodologies would be in preparing students for the state examinations. A seven-point response scale was utilized with the Likert-type questions as the authors felt it was important to allow the teachers to express their feelings adequately and so did not want them to feel restricted by providing fewer response options. The typical answer options, which varied slightly depending on the statement of the question (see **Table 4**), were Totally Agree, Mostly Agree, Somewhat Agree, Neutral, Somewhat Disagree, Mostly Disagree, and Totally Disagree. In order to determine whether the questions all measured the same latent variable a Cronbach's alpha was run on the sample. The Cronbach's alpha coefficient was 0.746, which indicated an acceptable degree of internal consistency between the questions (Nunnally, 1978).

The multiple choice questions were utilized to ascertain information such as the level that the teachers spent the majority of their time teaching at and also whether or not they felt the "old" traditional approach to mathematics instruction was effective in preparing students for the newly revised state examinations. Additionally teachers were asked to provide insight regarding their teaching colleagues and whether or not they felt that they had adapted their teaching to align with the goals of the reform and to provide some indication of the effort that they felt their colleagues had put in to embracing the new reform.

Two of the Likert-type questions provided to the teachers are shown here along with one of the open-ended questions as samples:

To what extent do you believe your mathematics teacher colleagues and friends have embraced the goals of Project Maths?

How effective do you believe a more traditional approach to the teaching of mathematics (which includes more teacher modeling and student direct practice) is in preparing students for Junior Certificate and Leaving Certificate examinations?

What would you say are the most prevalent obstacles, if any, to effectively implementing the pedagogical shifts associated with Project Maths?

A link to the online survey was disseminated via e-mail to a convenience sample of 800 mathematics teachers who were registered with the IMTA. A total of 154 teachers (19.25%) responded to the request for participation with 147 teachers (18.38%) completing all the questions in the survey. Although there is no universally accepted standard regarding response rates (Nulty, 2008; Carley-Baxter et al., 2009) this response rate could be considered low. Follow up attempts to encourage a higher response rate from teachers, and to minimize the possibility of non-response bias, proved unsuccessful. Although the response rate could be considered low, it is worth noting that the IMTA is a national organization with branches and membership all over Ireland and hence the respondents to the survey can be viewed as being representative of the population of post-primary mathematics teachers in Ireland. Unfortunately it was impossible to formally check the representativeness of the sample as there are no official numbers regarding how many post-primary teachers of mathematics there currently are in Ireland. Additionally, it was not possible due to privacy considerations to gain access to more detailed information relating to the convenience sample of IMTA members.

TABLE 2 | Example of analysis leading to generation of category/theme.

Original Text	National school teaching—students are not coming in with the basic concepts and mathematical facts they need to understand the basics in first year maths. Therefore, they are always playing catch up. No matter what way you address Mathematics in post-primary level, learning will not improve until the issues at primary level are addressed
Condensed Meaning Unit	Poor student knowledge entering post-primary education
Code	Student knowledge
Category	Lack of student knowledge

The responses to the Likert-type data were tabulated using SPSS, version 23. Descriptive statistics in the form of frequencies and percentages were generated for each of the response options. Further analysis to check for differences in responses among teachers depending on their length of service was also conducted but this yielded no difference between the cohorts. The qualitative data from the two open-ended questions were downloaded for viewing and analysis. Thematic analysis was conducted on the data to gain insight into the responses of the participants. Initially the data were read and re-read in an attempt to gain an understanding of what the respondents were saying. Initial hand notes were taken as the main points that the respondents were talking about became apparent. Following this the data were downloaded into MS Excel and further analyzed. Condensed meaning units were created for each response in an attempt to create smaller blocks of text that were still true to the original meanings portrayed by the respondents. Next the condensed meaning units were provided a label, or code, and following this these codes were grouped into categories, or themes. An example of this process is shown in **Table 2**. Frequencies, or percentages, of respondents who presented a similar point of view were also recorded so that we could quantify the strength, or popularity, or certain viewpoints. Finally, quantitative data were used to complement the insights gained from the thematic analysis of the qualitative data. This process aimed to achieve triangulation and thus strengthen the basis for conclusions drawn throughout this study.

FINDINGS

The authors are cognisant of the subjective nature of the questions utilized within the survey and of the responses offered by the teachers, and so caution must be displayed when interpreting the responses from the survey. To begin we sought to

TABLE 3 | Level teachers spend the majority of their time teaching at.

	Frequency	Percent
Transition and leaving certificate	3	2.0
Leaving Certificate	64	43.5
I teach all three levels	25	17.0
Junior and leaving certificate	35	23.8
Junior cycle	12	8.2
Missing	8	5.4
Total	147	100.0

provide some insight into the cohort of teachers who responded to the survey. The 147 teachers were asked to identity at what level[2] of the post-primary education syllabus they spend the majority of their time instructing mathematics. The results are shown in **Table 3** and highlight that although teachers who instruct at all levels of the syllabus responded to the survey, a significant number of the responding teachers (43.5%) only teach on the Leaving Certificate programme in the 2 final years of post-primary education. Additionally the teachers were asked whether or not they were specialist mathematics teachers, or whether they were out-of-field teachers of mathematics (Ní Ríordáin and Hannigan, 2009), which had been highlighted as a significant problem in Ireland prior to the introduction of Project Maths. From the 147 respondents over 93% ($n = 137$) of them held a specialist qualification to teach mathematics up to Leaving Certificate level.

To provide insight to answer the first research question, the teachers were asked about their level of agreement with the goals of the new curriculum. These goals include more focus on student conceptual understanding of mathematics in conjunction with procedural understanding; more use of context and applications of mathematics during the instruction of mathematics and increased usage of problem solving and more student-centered investigative learning. Just over 84% ($n = 122$) of the surveyed teachers said that they somewhat, mostly or totally agreed with the goals of the new curriculum, as seen in **Table 4**. Conversely, 8.3% ($n = 12$) of the surveyed teachers highlighted that they somewhat, mostly or totally disagree with the goals of the new curriculum. Within the open-ended questions some teachers provided more insight into their negative perception of the new curriculum by saying that they had a "*lack of belief that it is really that effective*" (Teacher 30), whereas another teacher stated that "*it is impossible to implement a flawed and negative system, when the parameters on which it was based were false*" (Teacher 133).

When further asked to consider how well they believe their colleagues had embraced the goals of the new syllabus 71.7% ($n = 104$) of teachers said that they felt their colleagues had somewhat, mostly or totally embraced the new curriculum goals, with 43.4% ($n = 63$) of the responses lying in the "somewhat embraced" category. Contrastingly, 23.4% ($n = 34$) of the teachers responded that they felt their teacher colleagues had somewhat, mostly or totally not embraced the goals of the new reform, which, 5 years after the introduction of the reform, is a worrying statistic. Analysis of the qualitative results support this finding and show that many teachers felt their colleagues have yet to make sufficient effort to engage and implement the new reform.

> *Some teachers that I have met will openly admit that they have taught the old way far too long to change now.* (Teacher 73)

When asked to further consider how well they felt their colleagues had adapted their teaching methodologies to include an emphasis on both conceptual understanding and procedural fluency 68.7% ($n = 101$) of the teachers felt that this had been somewhat, mostly or totally implemented by their colleagues. Contrastingly, 27.2% ($n = 40$) of the teachers felt that their colleagues had made insufficient efforts to adjust their methodologies, which suggested that most teachers felt that there was some effort being made by their colleagues to adjust their methodologies to align with the goals of the new curriculum, but that there was still some work needed in this area.

When questioned on how effective they felt the approach to teaching advocated in the new curriculum will be on student learning and their performance in the state examinations, 44.4% ($n = 64$) of the teachers responded that they felt the new approach would be somewhat or mostly effective (note that no teachers opted for the totally effective response in this case). Since the alteration of the state examinations was a key objective of the new curriculum, more insight into this topic was received from one of the open-ended questions that asked teachers "Do you believe the formal examinations in Ireland are aligned to the goals of Project Maths?" Just over 50% ($n = 73$) of the teachers answered that they believed, or somewhat believed, that there was alignment between the state examinations and the overall goals of the new curriculum. Although half of the surveyed teachers felt that the state examinations were somewhat aligned with the curriculum goals, many teachers believed that the demands on students regarding literacy, problem solving, and the need to be able to see and make links between different areas of mathematics to solve questions was too challenging, especially for the less-abled students.

> *"There is a much better understanding of the links between the strands but this really suits the more abled student. Weaker students find the constant cross between strands very confusing. The context and application section, though very ideal, is proving a step too far."* (Teacher 23)

> *"Students still find it difficult to identify what the questions are actually asking in some instances. Some issues with literacy."* (Teacher 142)

In contrast, when asked how effective they believed a more traditional teacher-directed instructional approach, which was reportedly utilized extensively by Irish mathematics teachers

[2]In Ireland there are 3 levels within post-primary education. The Junior Cycle, Transition Year and the Leaving Certificate. The Junior Cycle (lower secondary education) is a three year-long programme studied by students between the ages of 12/13 and 15/16 years. Transition Year is a one-year programme taken after the Junior Cycle and before the final two year Leaving Certificate programme.

TABLE 4 | Likert-type survey questions and frequency of responses.

Likert-Type Questions	1*	2	3	4	5	6	7
The goals of Project Maths include more emphasis on student conceptual understanding of mathematics in conjunction with procedural understanding, increased use of contexts and application, problem solving and student-centered investigative learning. To what extent do you agree with these goals?	22	74	26	11	4	6	2
To what extent do you believe your mathematics teacher colleagues and friends have embraced the goals of Project Maths?	5	36	63	10	13	16	2
To what extent do you believe your mathematics teacher colleagues and friends have been able to adapt their teaching with fidelity to the goals of Project Maths to include an emphasis on both conceptual understanding and procedural fluency?	3	28	70	6	22	14	4
How effective do you feel the approach Project Maths advocates will have on student learning and scores on Junior Certificate and Leaving Certificate examinations?	0	25	39	28	25	19	8
How much of an effort do you sense your mathematics teaching colleagues and friends have put into adapting their teaching to align with Project Maths goals?	23	49	38	14	6	3	2
How effective are the Project Maths support materials you currently use in assisting your implementation of the new principles of Project Maths?	4	21	70	10	17	18	6
How effective has been the effort to train out-of-field (non-specialist) mathematics teachers in mathematics content material and pedagogical material on overall student learning?	3	15	22	74	14	17	0
How effective do you believe a more traditional approach to the teaching of mathematics (which includes more teacher modeling and student direct practice) is in preparing students for Junior Certificate and Leaving Certificate examinations?	13	66	55	3	7	3	0
How effective have your Project Maths Modular Workshop days been in helping you grasp and apply the concepts of Project Maths?	10	47	57	10	15	6	0
How much longer do you feel it will take teachers in your school to fully apply the reform components of Project Maths into their normal class teaching sessions?	15	19	26	40	16	10	20

**1, Totally Agree/Effective; 2, Mostly Agree/Effective; 3, Somewhat Agree/Effective; 4, Neutral; 5, Somewhat Disagree/Ineffective; 6, Mostly Disagree/Ineffective; 7, Totally Disagree/Ineffective.*

teaching prior to the introduction of the new curriculum (Conway and Sloane, 2005), is in preparing students for the state examinations over 91.2% ($n = 134$) of the teachers responded that they felt it was a somewhat, mostly or totally effective teaching approach. The qualitative results support this finding as Teacher 19 pointed out that *"some questions really assess goals very well, some encourage me as a teacher to return to older approaches."* Other teachers were more critical of the attempts to align the curriculum goals and the state examinations. They highlighted the apparent disconnect that exists between the two and how the syllabus and teaching methodologies have evolved but that the final state examination has not.

> *"There is a disconnect between the student-centred ideology espoused by Project Maths and the over whelming nature of the compulsory totality displayed in the exam papers."* (Teacher 54)

Research question 2 was selected to uncover the obstacles that teachers encountered when implementing the new curriculum. Teachers were asked to answer the following open-ended question: "what would you say are the most prevalent obstacles, if any, to effectively implementing the pedagogical shifts associated with Project Maths?" Three main themes were identified within the qualitative responses. Almost 64% of the teachers ($n = 94$) made reference to the fact that they believed the syllabus was too long to be covered in the time provided.

> *"The length of the course and the pedagogies being advocated are not compatible."* (Teacher 109)

The second theme, mentioned by 43.5% ($n = 64$) of the teachers, is closely related to the first theme and raises the point that teachers felt there was not enough time provided to cover the material and address the shift in pedagogical style advocated as part of the curriculum change.

> *"The changes to the course are apparently for the better of the teaching and learning of mathematics but the size of the course and the methods by which teachers are to teach it leave very little time for the students to actually fully grasp the Project Maths course."* (Teacher 80)

The third theme highlighted by 26.5% of the teachers ($n = 39$) highlighted the need for more in-service training and resources,

with many teachers voicing the opinion that they had received insufficient or inadequate training.

"Insufficient training offered to teachers." (Teacher 111)

It is interesting to note that 94.5% ($n = 139$) of the teachers stressed the need for an increase in the number of class periods across all student years to better allow them to engage with the new curriculum goals.

Finally, the authors set out to find out how much longer the teachers felt it would take to fully apply the reform components of the new curriculum. Almost 80% of the teachers said that within the next 4 years they believed that the reform components would be fully implemented into the normal everyday teaching activities of teachers. In contrast, almost 15% of the teachers said that they believed it would take at least another 6 years before the reform components would be fully integrated and implemented by all teachers.

DISCUSSION

This research set out to gain insight into the level of agreement mathematics teachers displayed for the goals of a newly introduced curriculum in Ireland, 5 years after its introduction. In this study 84% of participating teachers said that they somewhat, mostly or totally agreed with the goals of the new curriculum, which is an encouraging finding. However, there appears to be some contradiction in the responses as less than half of teachers (44.4%) believed that the new teaching methodologies being endorsed by the curriculum would impact positively on student learning. This lack of agreement between policy and practice in education is a common occurrence, particularly when a new curriculum reform has been introduced (Cuban, 1993; Handal and Herrington, 2003), but it is a worrying statistic as it can ultimately lead to teachers feeling anxious and uncertain regarding how best to implement the reform (Guskey, 1986).

Within the privacy of their classrooms many teachers remain unconvinced as to the perceived benefits for their students that will be acquired by adjusting their pedagogical practices. In Ireland this has resulted in teachers being hesitant to move away from a behaviorist style of instruction toward the more constructivist approach advocated by the reform. The state examinations in Ireland also heavily influence the beliefs and practices of teachers, which is problematic as only 50% of those surveyed believed that there was alignment between the state examinations and the new curriculum goals. This perception among teachers regarding the importance of examination-dominated teaching was also found to be a barrier to curriculum reform by Memon (1997). Confounding this perceived misalignment is the fact that over 91% of the teachers highlighted that they felt that the old teacher-directed approach to instruction would be just as effective in preparing students for the state examinations as the instructional approaches advocated within the new reform. Memon (1997) again listed the importance that teachers placed on the old methodological approaches as a key instructional factor that can impact on a new educational reform.

The findings of this research study are further supported by the results of an additional analysis conducted on the PISA 2012 results (OECD, 2016), which found that in a study of over 70 countries Ireland had the highest ratio when comparing the usage of teacher-directed instruction strategies against student-oriented instruction strategies. Even though Ireland's teacher-directed instruction score (60.86) was ranked just below the OECD average (63.32) when this was compared to the student-oriented instruction score (10.28), which was significantly below the OECD student-oriented instruction average (21.46), this resulted in Ireland having the worst ratio among the 70 countries. This shows that there was a significant difference between the frequency of usage of teacher-directed instruction as opposed to student-oriented instruction 2 years after the introduction of the reform, which again highlights that teachers are slow to move away from the old, trusted instructional approaches. Additionally, this report found that Ireland also ranked highest in terms of the ratio between self-reported memorisation strategies and elaboration strategies being employed by students in the classroom. Elaboration strategies, according to PISA [(OECD, 2016), p. 49], are defined as strategies that "encourage students to make connections among mathematics tasks, link students' learning to their own prior knowledge and real-life situations, and find different ways of solving a problem." The Project Maths curriculum emphasizes all of these traits as part of the key skills that students need to master as part of the curriculum, yet based on the analysis from this report it appears that there is a still a long way to go toward achieving this objective. Ireland's individual self-reported memorisation score (39.22) was above the OECD average of 31.21 and its elaboration score (15.58) was below the OECD average (20.50). Overall, in terms of the employment of memorisation strategies as opposed to elaboration strategies, Irish students still report that they are placing more emphasis on learning material off by rote rather than trying to understand and make connections between the content covered.

Although there appears to be strong agreement amongst the teachers regarding the importance of the general goals of the new reform, there appears to be less agreement regarding how best to achieve these goals at both the instructional and organizational levels. Prendergast and Treacy (2018, p.12) investigated how well teachers have altered their approach to the instruction of algebra as part of the curriculum reform in Ireland and found that "*teachers are trying to do new things but they're not really sure what they are doing or supposed to be doing."* This uncertainty from the teachers regarding how best to implement the new curriculum is not uncommon (e.g., Fetters et al., 2002; Handal and Herrington, 2003), but it does lead to doubts and anxiety, which may impede and delay the successful implementation of a new reform.

In terms of the time allocated to mathematics instruction, a recent study in Ireland found that although the proportion of time is in close alignment with the OECD average, there are several areas of concern regarding mathematics instruction time in Ireland (Prendergast and O'Meara, 2017). One of the main concerns is that the time allocated to mathematics varies from school to school, as the decisions relating to class time for curriculum subjects are made at school level in Ireland (Eurydice Network, 2014), and this can result in significant variations in the

allotted time between schools. Considering the goals of the new curriculum, which advocate an increased emphasis be placed on mathematical problem solving, the development of conceptual understanding, and the development of a more student-centered classroom, all of which take more time to implement (Cosgrove et al., 2012; Jeffes et al., 2012), it is unsurprising that so many of the surveyed teachers have highlighted the need for more time to be allocated to the instruction of mathematics under the new reform.

One final significant point of note is that the majority of the issues voiced by the teachers in this study could be classified, according to Fuller (1969), as *task concerns*; that is, concerns focused on the day-to-day duties associated with teaching. Sixty-four percent of the participants surveyed said that the syllabus was simply too long; 43.5% said there is not enough time in the school calendar to cover the content, whereas 94.5% believed that an increase in weekly class periods would help alleviate some of this pressure. Five years after the implementation of the curriculum reform almost none of the teachers surveyed talked about a lack of information or awareness regarding the goals of the reform. This evolution in teachers' thinking beyond what Fuller (1969) termed *self-concerns* is a positive transition, and as Van Den Berg and Ros (1999) and McKinney et al. (1999) highlighted, it is essential if a reform is to succeed and become established. Tunks and Weller (2009) further indicated how this evolution in teachers' thinking will only occur if they have been continuously and substantially supported in the early implementation stages of the reform. Charalambous and Philippou's (2010) research also supported how important the notion of early and continuous support is for teachers and found that 5 years after the introduction of a new mathematics curriculum in Cyprus many of their teachers were still struggling and seeking additional information regarding the goals of the reform. One explanation for the Irish teachers not mentioning issues related to awareness and information regarding the goals of the reform could be due to the frequency and number of modular workshops that were offered to the teachers, and the fact that approximately 78% ($n = 114$) of the teachers found the workshops somewhat, mostly or totally effective in helping them grasp the key concepts of the new reform. From the responses to the open-ended question that focused on the obstacles that the teachers face when implementing the reform, there is evidence that the focus of some teachers ($n = 8$) has progressed beyond classroom-based issues to considering how the reform will impact on their students. These teachers commented that the demands of problem solving and the reading requirements on the examination papers were too great, particularly for less-abled students. This finding is further reinforced by the fact that only 44% of the teachers agreed that the altered teaching methodologies advocated in the new reform would have a positive effect on student learning.

CONCLUSIONS

James and Pollard (2008, p. 5) stated that "learning has both personal and social aspects and involves the development of knowledge, dispositions, and practices." It could be argued that the same is true for teaching, and hence only by considering teachers' beliefs and perceptions of teaching and learning will we be able to effect long-term, meaningful curriculum change. Stipek et al. (2001) found that teachers with more traditional beliefs [e.g., mathematics is a set of operations to be learned; students' goal is to get correct solutions; the teacher needs to exercise complete control over mathematics activities; mathematics ability is fixed and stable; and extrinsic rewards and grades are elective strategies for motivating students to engage in mathematics (Stipek et al., 2001, p. 222)] tended to be more traditional in their classroom practice. That is, their beliefs altered their perception of effective classroom practice. When faced with a curriculum reform that seeks to alter classroom practice it is therefore imperative that we consider teachers' beliefs and perceptions and investigate how we might go about encouraging teachers to alter these to align with the goals of the new reform. Gaining information regarding teachers' perceptions of the reform and its effect on classroom practice can be a valuable stepping stone toward implementing a course of action designed at altering their overall beliefs regarding the reform.

Continuing Professional Development (CPD) is a key vehicle that can help teachers to alter their beliefs about mathematical instruction whilst simultaneously helping teachers' perceptions of the new curriculum to progress from personal considerations to classroom-based considerations and even onto impact-based considerations. There appears to be evidence in Ireland of this progression, 5 years after the introduction of the reform, as the majority of teachers' issues at this stage could be classified as classroom-based. This could be attributed to the number and frequency of instructional workshops designed to help teachers adjust to the new curriculum. However, it should be noted that the number and frequency of these workshops has decreased in the last 2 years, and the impact of this on teacher practice has yet to be measured. The reduction in the frequency of CPD courses being offered to mathematics teachers could be a potentially harmful occurrence as educational reform requires significant and lasting support as the pressure to revert to traditional practice is always present and this could erode the reform even after it is put in place. In this study 26.5% of the teachers voiced the need for more in-service training and resources, which highlights the emphasis that many teachers place on CPD and how they view it as an essential aid in assisting them to interact and implement the reform. Therefore, it will be important to monitor teachers' levels of support for the reform in the coming years to see if this decline in the number of CPD courses on offer has had any effect on their support of the reform, or on the outstanding issues currently being expressed by teachers.

Finally, as previously stated, many countries have altered their mathematics curriculum in attempts to develop more learner-autonomy whilst simultaneously developing the skills to solve mathematical problems in different contexts. These changes in policy direction have often led to curriculum writers calling for the promotion of more "student-centered" methodologies as opposed to "teacher-centered" methodologies. Unfortunately, the exact definition of what constitutes student-centered or

teacher-centered methodologies isn't as clear-cut as we might think (Muijs and Reynolds, 2017). Regardless, these terms appear frequently in policy and curriculum documents calling for change and generally present student-centered and teacher-centered methodologies as being mutually exclusive, which is not always the case. Perhaps to enhance the quality of instruction and improve learning, it is time that we instead shifted our focus away from these "hold-all" terms and instead focused on promoting the instructional approaches that help to encourage student-autonomy and learning, regardless of which side of the fictional student-centered/teacher-centered methodologies fence they lie on.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the Faculty of Science and Engineering Research Ethics Committee at the University of Limerick with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Faculty of Science and Engineering Research Ethics Committee at the University of Limerick.

AUTHOR CONTRIBUTIONS

JF proposed the idea for the research and created the instrument to measure the perceptions of the teachers and collected the data. PJ and OF reviewed the proposal and suggested edits to the initial version of the instrument. PJ performed the analysis of the data and wrote the first draft of the manuscript. JF and OF reviewed the manuscript and edited sections of the manuscript. All authors contributed to manuscript revision and approved the final submitted version.

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