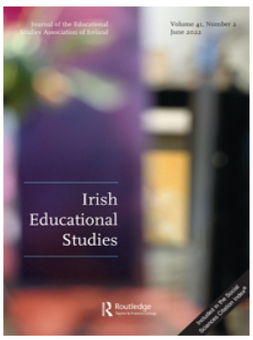

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The challenges of teaching maths in Irish in Irish-medium education

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ABSTRACT

Despite the growth and popularity of Irish-medium Education (IME) in Northern Ireland, the sector has not received the same levels of state support and funding as has heritage language education in the rest of the UK and the Republic of Ireland. Educating children in an immersive language setting, particularly in a minority or endangered language, is still regarded as disadvantageous to the learner, and that bilingual language education will hinder academic attainment, including maths. We present findings from thematic interviews with 11 primary teachers' perceptions on the challenges of teaching maths in Irish, and how to help the sector develop language skills in, and resources for, teaching maths in the primary curriculum in Northern Ireland. The challenges that emerged from the thematic interviews, include finding teachers with the requisite language skills to teach maths, training and support for Irish-speaking maths teachers, and how children can acquire the right kind of fluency to engage in maths learning.

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Irish-medium education; minority-languages; Irish language literacy; language-as-resource; teaching resources in Irish; teacher perceptions of maths teaching

Introduction

Education through the medium of autochthonous minority languages, such as Irish, Gaelic, Welsh, in the United Kingdom and the Republic of Ireland, Basque and Catalan in Spain, and Breton in France, have become popular in recent decades. In Scotland, for example, Gaelic Medium Education (GME) is now a well-established sector in Scottish Education having begun in primary schools in the 1980s (Education Scotland 2021). Often cited as a success story in minority language revitalisation, education through Welsh has grown rapidly since the first state funded Welsh-medium primary school opened in 1947 and is currently the subject of a significant action plan of the Welsh Government (Llywodraeth Cymru 2017).

In the Republic of Ireland, the restoration of the Irish language has been a key policy objective of successive governments since the foundation of the State in 1921. In order to halt the decline of Irish, the language was declared the national and first official language of Ireland in accordance with Article 8 of the Constitution of Ireland. The *Education Act*

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1998 states, for example, that every person involved in the implementation of the Act should contribute to the 'extension of bilingualism in Irish society and in particular the achievement of greater use of the Irish language at school and in the community' and 'to the maintenance of Irish as the primary community language in Gaeltacht areas' (Irish Statute Book).

In Northern Ireland, the Irish-medium sector has continued to grow since the first 'bunscoil' (primary school) opened in 1971 in West Belfast. Despite its growth and popularity, even in the late1990s, Irish-medium Education in Northern Ireland had not received the same levels of state support and funding as had heritage and minority language education in the rest of the UK and the Republic of Ireland. Irish received official recognition in Northern Ireland for the first time with the signing of the Belfast Agreement, also known as the Good Friday Agreement, in 1998. The Belfast Agreement helped to create a political environment favourable to IME; it called on '[a]ll participants to recognise the importance of respect, understanding and tolerance in relation to linguistic diversity, including in Northern Ireland, the Irish language, Ulster-Scots and the languages of the various ethnic communities … ' (Article 3, *Economic and Cultural Issues*). The *Education (Northern Ireland) Order 1998* states that: 'It shall be the duty of the Department (of Education) to encourage and facilitate the development of Irish-medium education' (UK Gov 1998).

The devolved governments and assemblies of Scotland and Wales, and the government of the Republic of Ireland and the United Kingdom, have accorded Gaelic, Welsh, Irish and Cornish equal legal status to English, not only out of respect for linguistic and cultural diversity, and to preserve richness of expression, but also to ensure the right to be educated in those languages. In 2001, the government of the United Kingdom ratified the European Charter for Regional or Minority Languages. Irish (in Northern Ireland only) was specified under Part III of the Charter, giving it a degree of protection and status comparable to Scottish Gaelic and Welsh.

In this paper, we present findings from primary teachers on their perceptions of, and reasons for, the challenges of teaching maths through Irish in Northern Ireland. We interviewed 11 teachers in six primary schools in (three urban and three rural) and two schools in the Republic of Ireland (one urban and one rural) across different counties. The interviews were based on thematic questions which sought teachers' views on the status of the language, the value of bi-lingualism, and how to help the sector develop skills in, and resources for, teaching maths in Irish-medium Education (IME), including language proficiency, in Key Stages 1 and 2 (KS1/2; ages 5–7, and 8–11) of the Northern Ireland primary school curriculum.

The research is important for three reasons. First, educating children in an immersive language setting, particularly in a minority or endangered language where the minority language is politically contentious (see MacKenzie, Engman, and McGurk 2022), is often erroneously regarded as disadvantageous to the child's education. We assess these claims against the challenges of teaching in the IME sector in this part of the United Kingdom which, until recently, was beset by sectarian violence (known euphemistically as 'The Troubles' between 1969 and 1998), and suppression of and suspicions about the Irish language (Mac Ionnrachtaigh 2021; McVeigh and Rolston 2021).

Second, and relatedly, the Irish language in Northern Ireland has not yet been granted official language status. The 'Acht na Gaelige' (Irish Language Act) giving Gaeilge and

English equal status contributed to a three-year (2017–2020) collapse of the power-sharing government in Northern Ireland (MacKenzie, Engman, and McGurk 2022). The British government had promised to deliver the Act before the Northern Ireland's Assembly elections in May 2022 but in March 2022 confirmed that this would not happen (Hargan 2022). The lack of status for, and deligitmisation of the language, along with the erroneous beliefs about bilingualism, has had implications for resourcing IME schools and consensus on developing appropriate linguistic resources for teaching maths to a degree that the teachers in the Republic have not encountered.

Third, this research contributes existing research on the value of immersive education and the importance of striving to support and protect minority and heritage languages against global homogenising forces that may all but wipe out linguistic diversity. There are significant challenges to teaching subjects in minority languages. Irish, like many minority languages in the UK and worldwide, are endangered for a variety of complex reasons, including neglect, historically unjust and unequal power relations between language speakers, active suppression of the language across the institutions, and homogenising state policy. This has been the experience of Irish language speakers in Northern Ireland. As with language reclamation efforts elsewhere, Irish-language immersion schools have sought to reverse the effects of language decline (Ó Laoire 2012), but finding teachers with the requisite language skills to teach subjects like, for example, maths and the sciences, is challenging. The 2011 UK Census showed that just over 6.05% of the population in Northern Ireland could speak the language, while only 0.2% spoke it at home (NISRA 2011). In the Republic of Ireland, the 2016 Census showed that only 1.7% of the population spoke Irish (Irish Central 2014).

Research for the European Parliamentary Research Service, for example, has shown that nearly half of the six thousand languages spoken across the world are in danger of disappearing (Passikowska-Schnass 2016). The research we present, therefore, is not simply about teaching maths in Irish in a particular and unique part of the UK, but about the historical, political and global implications for and consequences of preserving a language in a world where 97% of the world's population speaks only 4% of the world's languages (UNESCO 2003). We regard language in this research, following the classic work by Ruíz (1984), as a resource and a right. We will discuss these ideas and their relevance to our research focus in the next section.

Literature review

The value of bilingualism

We begin the literature review with an overview of the value of bilingualism to educational attainment, including mathematical competence, given the still prevalent view in Northern Ireland that education in the Irish language is disadvantageous, especially to children from monolingual homes. Early attempts to explain low academic achievement of many minority language children tended to attribute a role to linguistic factors (Cummins 1979). There was an intuitive belief that if bilingual children were weak in one language, the development of their mathematical abilities (and other academic subjects) would be hindered, particularly with word-solving problems. The belief was that if word-solving problems are derived from ordinary language (as

opposed to the unique language of mathematics, say), then mastery of mathematical skills would be dependent on the mastery of the language in which the problem was to be solved. Bilingualism, as Cummins' research acknowledged, was judged to be a source of confusion and an impediment to language proficiency, to the extent that a child paid for her/his second language skills (L2) with a decrease in her first (L1) (Cummins 1979, 222).

In an early, widely cited and influential study in the literature on bilingualism, Mcnamara (1967) reported that, while bilingualism had no impact on children's mechanical ability in computational arithmetic, it did impair their ability to solve mathematical word problems. The evidence for the claim came from an overview of the research at the time, and from Macnamara's own large-scale study of English-speaking children in Irish language schools, in which he tested word problems in arithmetic. However, as Bialystok (2001) points out, the problem was not bilingualism but, rather, 'the use of a language for a complex educational purpose that exceeded the children's proficiency in that language' (109). Children's limited performance in such a task would be hindered whether the child had only one language or many. Linguistic proficiency needs, therefore, 'to be adequate for the conceptual demands of the task' (109), including language that is contextualised to the immediate environment.

Another important study came from Secada (1991) who sought to explore the relationship between bilingualism and arithmetic word problem solving among low achieving Hispanic children in the Chicago area. The underachievement in maths of Hispanic children from poor socio-economic backgrounds is well documented and many are classified as limited in English Language Proficiency (ELP). The mathematical education provided to low-achieving children tends to focus on acquiring basic skills at the expense of problem solving and of other advanced mathematical content. The assumption is that low-achieving pupils (in compensatory education schemes in the USA) cannot solve problems before they have mastered the basic skills. Indeed, because the curriculum ignores the competence that first-grade pupils possess, many pupils will experience future failure in maths.

Secada (1991) tested 45 first-grade Hispanic children in both Spanish and English for language proficiency and then administered a series of arithmetic word problems to solve in both languages. The children were less proficient in Spanish than in English. Two main findings emerged. First, children could solve the problems equally well in both languages; if they could solve a given problem in English, they could also solve it in Spanish. Second, there was a small but significant effect showing a relation between greater degree of bilingualism and enhanced problem-solving ability. Secada concluded that the problem-solving ability of the bilingual children was equivalent to that of their monolingual peers. His study also showed that lower levels of language proficiency did not interfere with the ability of these children to solve the problems in their weaker language, English.

Using these results to address the question of why this might be case, Secada concluded that the pupil who is less proficient or limited in the second language is *becoming* bilingual and is gaining access to the cognitive benefits that accrue to bilingual children. Children move rapidly between the languages to find a word or concept that can be used to provide meaning or solve problems in the other (the cognitive benefits of bilingualism will be discussed in further detail below). However, it should be noted that the dominant

mode of instruction in Secada's study was English, and the dominant language in the United States (US) is, of course, English. The results may be different if [becoming] bilingual pupils are being educated in a minority language and for whom the minority language is their weaker language, as in the case in Northern Ireland and the Republic of Ireland where English is the dominant language.

Secada's study contradicts the findings by Mestre (1998) who also conducted research with Hispanic-English bilingual children in the US. Mestre identified four forms of language proficiency that are required to solve these problems: (1) the ability to read and comprehend a problem; (2) familiarity with technical language. For example, 'product' has a specific meaning in maths – the operation of multiplication. In ordinary language 'product' means an item to be sold; (3) syntactic proficiency – how mathematical and ordinary language are structured to form a text; and (4) comprehension of math symbols and how they are used in combination with numbers (215–216). Mestre claimed that all four proficiencies were compromised in bilingual children, a finding that seemed consistent with Macnamara's claim in his 1966 study.

Mestre based his research on Hispanic bilingual children who were studying in English and for whom English was their weaker language. He found that bilinguals with comparable mathematical skills to monolingual children tended to solve mathematical problems incorrectly because of poor language proficiency and had reading speeds slow enough to interfere with performance in timed problem-solving tasks. Further, though two of the language proficiency categories, technical (2) and symbolic language proficiency (4), are domain dependent, to learn these 'languages', pupils must be proficient in the first, English. Not only do pupils need technical proficiency to succeed mathematically, they must first become proficient in English before they can attain the required technical threshold. Bilingual children are, therefore, disadvantaged, Mestre claimed.

The children in Secada's should have encountered the problems described by Mestre in his study, but they did not. This seems contradictory but understanding precisely what enhances or inhibits academic competency is complex. According to Bialystok (2001), if language proficiency in the home language (L1) is at least adequate for understanding the problem, bilingualism should have no effect on mathematical problem-solving. Cummins, in his 1979 research, pointed out that the hypothesis that bilingualism is the cause of academic and cognitive confusion was, even at that time, contradicted by research that showed that bilingualism can positively influence cognitive and linguistic development. Further, socio-cultural effects, or the extent to which the home language is valued and respected by the community, whether teachers are sensitive to the values and traditions of the minority language community, or whether families feel compelled to discourage their children from speaking the home language, may play a more significant role in academic success than simplistic causal linguistic explanations, as important new research by McGurk has shown (2022 forthcoming). It may also help to understand how levels of proficiency in either language, both absolute and relative, affects problem solving maths.

Absolute and relative levels of proficiency: threshold levels of proficiency

Do children who maintain and develop their L1 (English) in school develop higher or lower L2 (Irish) levels of skills than those whose L1 (English) is replaced by their L2

(Irish) as in immersion programmes? Cummins' (1979) seminal research strongly suggested that cognitively and academically beneficial forms of bilingualism can be achieved only if the child has adequately developed first language, or L1, skills.

Cummins based his conclusion on the threshold level of linguistic competence hypothesis, which was an attempt to incorporate proficiency levels into predictions about the effects of bilingualism. This hypothesis assumes that there is a threshold level that bilingual children must achieve for the benefits of becoming bilingual to influence their cognitive growth and avoid cognitive defects such as poor word recognition (Cummins 1979, 330). A prerequisite for attaining a higher threshold level of bilingual competence is development and maintenance of L1 skills. The child whose literacy skills is poorly developed in L1 will have difficulties mastering the content of other subjects, especially in subjects which require abstract thought such as maths and the sciences. Teaching that is discovery based, collaborative, and experiential can help overcome the challenges of print literary (such as through visual/audio methods); however, schools rely on printed text to teach and assess (Guerrettaz, Engman, and Matsumoto 2021). Reciprocal peer tutoring also has beneficial effects on language attainment (Thurston and Thurston 2015).

Three general aspects of children's knowledge of language which have been hypothesised as important for the acquisition of fluent reading are, first, *Vocabulary concept knowledge* (Cummins 1979). Vocabulary acquisition and comprehension play a strong role in how well a child can read in either L1 or L2. Teachers who help children explore, interpret, and extend the meaning of words thereby develop their reading skills. Although children with low literacy skills can decode the word, the meaning of the word and the concept, the symbol it represents are not available to them, or only in a limited or vague way. An example might be 'velocity'. The child may spell out, decode, vel-oc-i-ty but may not know what it means or how to calculate a problem based on the concept of velocity. Fluent reading comprehension is not possible if the reader does not understand the concept to which the word refers. Further, if the conceptual basis for abstraction is absent in L1, it will be absent in L2.

The second aspect that is important to fluent reading is the acquisition of certain *metalinguistic insights* about the nature of printed text. To understand the printed word, children need to understand that print is meaningful and that it is different to speech. Finally, and relatedly, the extent to which the child has developed the facility to process *decontextualised language* will determine the child's proficiency in reading. Written text is a representation of meaning ('the rabbit disappeared down the hole') and has a logical and semantic relation between the parts of the sentence (noun [rabbit], verb [disappeared], object [hole]) which the child must be taught to understand using increasingly complex texts as she progresses through the curriculum (Cummins 1979, 237). The child who comes to school able to understand that text is different from the spoken language, that text is meaningful, and who can, to some degree, process decontextualized language, will more quickly take-up the demands of L2 than the child who lacks these insights and facilities. As Cummins concludes, '[t]he fact that the children are already familiar with the concepts encountered in learning L1 means that their task is essentially learning a new label for an already existing concept' (240). For example, the English word 'rabbit' is 'coinín' in Irish; and 'velocity' is 'treolus'.

Of critical importance is that research has shown that children do not suffer any disadvantages from learning and using two languages, provided that one of their languages is established to age appropriate or proficient threshold levels. Children who have age-appropriate levels in at least one of their languages, will have access to the abstract concepts that are the currency of schooling, and which they can transfer to L2. Low thresholds of linguistic competence in one language will impair linguistic proficiency in the other because 'there is no language in which children are able to establish the cognitive systems that are at the base of academic functioning' (Bialystok 2001, 227). Therefore, if schools are to benefit from children's bilingualism, or are to avoid impairment because of it, 'the absolute proficiency level of at least one language is crucial', according to Bialystock. In other words, 'the balance between the two languages is less critical than is the need for one of them to be developed to a level that is sufficient for schooling' (228). What matters is the child's proficiency, not when the language is learned, or which language is spoken at home.

Success in school occurs when children develop the 'native' L1 (or L2) language to high levels of proficiency. Children who live in communities where education and achievement are strongly encouraged, and whose family is closely involved with their children's education, can develop high threshold levels of linguistic competence in the native language and, importantly, a positively motivated attitude toward school (McGurk 2022). Further, when these children attend school in the local language, even if that language is not spoken at home, their immersion is relatively straightforward and often successful (Bialystok 2001, 238–239). Bialystok (2001) advises that for children who live in communities where these conditions are not equally available, then the school 'must provide a more supportive and motivating environment to encourage the children and assist them in the educational challenges they face' (238). Our findings support Bialystock's claims.

The cognitive benefits of bilingualism

Lauchlan, Parisi, and Fadda (2013) provide supportive evidence of the cognitive benefits of bilingualism. They undertook research to investigate the benefits of bilingualism in children who speak the minority languages of Sardinian and Scottish Gaelic, in addition to their respective national languages of Italian and English. Scottish Gaelic and Sardinian are minority languages, spoken in countries in which English and Italian are recognised international languages. Of note, too, is that most research on the cognitive benefits of bilingualism are undertaken with children who speak in two or more dominant languages (Spanish, French, or Italian, for example), rather than in minority languages (Gaelic, Welsh or Irish, for example).

One hundred and twenty-one children across the two countries, both bilingual and monolingual, were given a series of standardised cognitive ability tests targeted at the four areas that have been shown to be advantageous to bilingual children: *cognitive control*, *working memory*, *metalinguistic awareness* and *problem-solving ability* (Lauchlan, Parisi, and Fadda 2013). Four tests were administered: the *Block Design* test in which children manipulate coloured blocks to reproduce patterns. This is a test of non-verbal, problem-solving ability that requires cognitive control. The *Digit Span* test, which requires children to orally repeat a series of numbers in the order presented, then in reverse. This tests working memory. In the *Vocabulary* test, children are asked to give

clear definitions of words. This is a metalinguistic skill of verbal ability and word awareness. In the *Arithmetic* test, children have to mentally solve a series of increasingly complex arithmetical problems. This is a test of mathematical problem solving and working memory.

Scottish bilingual children outperformed Scottish monolingual, Sardinian monolingual and bilingual children on the Vocabulary and Arithmetic tests, and performed significantly better than the two monolingual groups on the Block Design test. Overall, the bilingual children scored significantly higher than the monolingual children on Block Design and Vocabulary tests. In the other two tests, Digit Span and Arithmetic, the bilingual children scored higher than the monolingual children but not at a significantly statistical level.

The superior performance of the Scottish bilingual children can be attributed to the formal bilingual education Scottish children receive. Scottish children, on Lauchlan, Parisi, and Fadda's analysis, are 'balanced' bilinguals to a higher degree than are Sardinian children. Recalling Cummins' (1979) claim that there is a critical threshold of L1 ability that must be attained before the positive effects of bilingualism can be observed, it may be the case that the Sardinian children did not have the same command of oral and written Sardinian as they did in Italian. Lauchlan, Parisi, and Fadda concur with Cummins (1979) and Bialystok (2001) that in order to gain from the advantages of bilingualism, the speaker should be proficient in both languages.

Bilingualism and mathematical competence

Research has also established that bilingualism can benefit children's mathematical competence and achievement, particularly with respect to the development of a child's executive functions (EFs). EFs consist of inhibition (suppressing irrelevant information), updating (working memory such calculating sums), and mental set shifting (from addition to subtraction, for example). Numerous studies, according to Hartanto, Yang, and Yang (2017), have also demonstrated, with some consistency, that bilingual children outperform their monolingual counterparts on EF.

Hartanto, Yang, and Yang (2017) drew on two large-scale datasets collected in the US to examine the relationship between bilingualism and mathematical achievement among pre-schoolers, kindergarteners, and first-grade students (ages 4–7). In both studies, the researchers found that bilingualism positively predicted teacher-rated mathematical reasoning, emergent numeracy skills, and test scores on either mathematical word problems or standardised mathematical assessments. Further, the positive association between bilingualism and mathematical competence persisted through the transition period from kindergarten to first grade. These results suggest that bilingualism is favourable for children's mathematical reasoning and problem-solving skills.

Marian, Shook, and Schroeder (2013) examined the effect of bilingual education on mathematics achievement in students from the third ($n = 37$), fourth ($n = 19$), and fifth ($n = 19$) grades of a two-way immersion programme that combined the majority language (English) with a minority language (Spanish) in the USA. When bilingual students' scores were compared to those of monolingual students who were enrolled in mainstream classrooms in the third ($n = 574$), fourth ($n = 579$), and fifth ($n = 624$) grades, the results showed that bilingual students outperformed their monolingual peers.

Research has demonstrated a significant relationship between performance on mathematical word problems and language proficiency, and bilingual students with high proficiency in both Irish and English perform better mathematically. Ní Ríordáin and O' Donoghue (2009) conducted research in the Republic of Ireland specifically to examine the influence of language proficiency on performance of mathematical word-based problem solving of Gaeilgeoirí (students) in the transition to English-medium mathematics education at second and third-level education. Sixteen primary 7 pupils were recruited from Gaeltacht schools (Irish speaking areas) and 21 from Gaelscoileanna (immersion schools). A control group of monolingual English-speaking students ($n = 49$) was also used. The bilingual participants at second level had all studied mathematics through the medium of Gaeilge (Irish) at primary level, were now studying maths through English in their first year at second level education.

The participants completed a mathematics word problem test in Gaeilge (bilingual students only) and in English; and language proficiency tests in English and in Gaeilge (bilingual students only) The findings revealed that Irish-medium pupils' performance on mathematical word problems is related to their linguistic proficiencies in both languages. Gaeilge language proficiency (the language of learning) was found to be of more significance than proficiency in English, and the pupils' performance on the English version of the mathematics test was highly correlated with their performance on the Gaeilge version of the test. What seems evident in this study is that the greater the level of academic language proficiency in a student's first language (Gaeilge), the stronger the transfer of skills to the new language of instruction (English). However, when assessed through the medium of English, the Gaeilgeoirí experienced a disadvantage of 8.7% in performance on mathematical word problems (and see McGurk 2022). Ní Ríordáin and O' Donoghue (2009) suggest that improving language proficiency in English may improve the pupils' performance in mathematics through the medium of English. Improved language proficiency may also help to assess the student in their first language until they have mastered the language of mathematics in English. The key findings presented in this paper provide support for Cummins' Thresholds Hypothesis discussed above (see also recent work by Prediger 2019 on language responsive subject matter teaching).

Finally, national testing in mathematics and English reveals that students in Irish-medium primary education perform the same or better than students in all English-medium education in both mathematics and English (Gilleece et al. 2012).

Language-as-resource

The specific role of language in the teaching and learning of mathematics in bilingual contexts is now well established (Planas and Civil 2013; Ní Ríordáin 2018). Research has helped to undermine the belief in language-as-deficit and to orientate it towards language-as-resource whereby linguistic challenges are seen as learning opportunities. Language-as-resource is defined as ' … a language-specific orientation consisting of the use of students' languages in classroom activity in ways that allow and maximise the generation and exploitation of maths learning opportunities' (Planas 2014, 55).

Planas (2014) suggests that language-as-resource consists in the use of students' languages in classroom activity that 'allows and maximises the generation and

exploitation of mathematics learning opportunities' (7) for thinking and doing, and particularly for learning and teaching mathematics. With respect to minority languages, language-as-resource can also 'have a direct impact on enhancing the language status of subordinate languages' (7).

Ní Ríordáin (2018) develops the concept of language-as-resource in her research by considering how specific features of the Irish language can support conceptual development in mathematics and aid the acquisition of mathematical skills in Irish medium settings. Ní Ríordáin argues that, in comparison to English, general syntactical features of the Irish language, such as sentence length, topic prominence and word order, lend themselves to easier interpretation of mathematical meaning. For example, many mathematical Irish words describe objects rather than simply label them. 'Velocity' in English means speed. In Irish, the conceptual and descriptive equivalent is 'treoluas', meaning 'direction speed' or 'the speed of something in a given direction' (315). The descriptive aspect of the word makes it easier for children to understand the conceptual meaning of the word, and so process the problem. Other features of the Irish language which supports language-as-resource is the word order in relation to number. Irish counts in units of ten. Forty-three pens, for example, is *tri pheann is daichead*, or three pens and forty. As Ní Ríordáin explains, the name, *peann*, is in the singular not the plural form, *pinn*, and plurality is expressed by the adjunction of a number (315). While the word order in counting could be challenging because it is so different from English, it is, Ní Ríordáin suggests, an opportunity to think about number sense and order (315).

In order to examine Irish-medium primary teachers' practices in teaching maths through the medium of Irish, Ní Ríordáin (2018) surveyed 315 teachers from 77 Irish-medium primary schools on teachers' self-reported practices on language-as-resource. The findings revealed that 92% of teachers recognised the importance of teacher talk in the classroom. However, only 36% of teachers reported using practices that reflected an understanding of how their talk affects bilingual students' learning in maths lessons (320). Teachers who understood that language is a resource for teaching maths did not simply rely on teaching terminology, but structured the learning through peer discussion and communication tasks.

In response to the question: 'Does the Irish language help develop mathematical concepts?' 41% said 'yes' (322). Explanations of how the language helps focused primarily on vocabulary and how some of the words describe the mathematical idea: 'Some of the mathematical words actually convey the idea and it can be very useful to highlight this to pupils' (T55, Gaeltacht, 322). However, 87% of respondents were unsure how syntactical features and specific characteristics of the Irish language could be used to support the teaching of mathematics (322).

If teachers are to exploit the benefits of bilingualism and classroom opportunities for learning, resources and professional development programmes need to be established that incorporate the development of pedagogical approaches that support a language-as-resource orientation. Vocabulary development is one measure of language proficiency, but approaches that are overly focused on vocabulary acquisition and translation constrict opportunities to use the language as a resource, and hinder pupils from learning maths. Teachers in Ní Ríordáin's (2018) research reported a lack of confidence in teaching contextualised problems because of language difficulties, suggesting a language-as-

problem rather than language-as-resource orientation. Further, since many of the responses were centred on linguistic difficulties, particularly of students with special education needs, opportunities to regard Irish-as-resource to teach maths were restricted. Developing a mathematical concept in one language should allow for that concept to be accessible in another language. However, both the mathematical concept and language need to be developed concurrently.

Research design

The research was commissioned by the Council for the Curriculum Examinations and Assessment (CCEA) in 2018, specifically curriculum designers whose remit is Irish-medium education who wanted to know the challenges and perceptions of primary teachers teaching maths in IME settings, along with their views on the resources required to teach the subject effectively and creatively, including linguistic resources. As we mentioned above, CCEA officials and teachers had expressed concerns that IME and bilingualism were perceived to be barriers to learning maths (and other subjects) and sought research which examined the veracity of such beliefs. Accordingly, the main research question for the research was: What are the challenges of teaching maths in Irish in Irish-medium education settings?

The three subsidiary thematic questions were: 1. Challenges to teaching maths in IME – linguistic (language threshold), familial and resources; 2. Teaching and learning resources; 3. Future developments to address linguistic thresholds, maths literacy, consistency in the use of agreed terminology.

Participants and data collection method

The researchers visited six IME primary schools in Northern Ireland (three urban and three rural) and two schools in the Republic of Ireland (one urban and one rural) across a number of counties. The schools had previously agreed to consider participating in the research through CCEA. In this sample urban is defined as being located in a location with a population greater than 4500 people, and ruralwith a population of less than 4500 people. These correspond roughly to urban-Band A–D and rural Band E–H in the Northern Ireland Statistical Record Agency (NISRA) definition (NISRA 2005). For comparability, the same classification was used for schools both north and south of the border. Further details about the demographics of the schools are not provided to protect the anonymity of schools and participants [there being only 28 Irish-medium schools in Northern Ireland (Education NI 2016)]. However, all the teachers we interviewed were Irish speakers and had studied in both Irish and English in Higher Education. Full Irish immersion at this level is not available in Northern Ireland, principally because the majority of teachers who want to teach in Irish are language specialists. The length of time the participants had taught in primary IME ranged from five to 30 years. Urban schools had a mean free school meal rate of 53.4% and the rural schools had a free school meal rate of 33.5%.

Semi-structured interviews were used to enable an open and explorative means by which to understand the issues facing teachers involved in teaching maths in KS1/2 in IME settings. A Key Stage in the curriculum of Northern Ireland, Wales and England refers to the set of skills and knowledge a student should develop at key stages in their

education. Key Stage 1 is taught to children aged 5–7 years old (Primary 1 and 2); Key Stage 2 is taught to children aged between 7–11 years old (Primary 3–6).

The interviews were conducted on-site, by two researchers (from a team of four) based at [NAME OF THE UNIVERSITY]. The interviews took place with key staff from each school between May and June, 2018. Where possible, at least one teacher from KS1 and one from KS2 maths were recruited. In total, 11 primary teachers were interviewed for approximately one hour each. Interviews were digitally recorded for transcription and then anonymised to protect the respondents' identities. Interview recordings were deleted following transcription.

Data analysis

Interviews were analysed thematically to draw out key, patterns, concepts and themes using Braun and Clarke's (2006) six phases of thematic analysis, namely: familiarisation with the data; generating initial codes; searching for themes; reviewing themes; defining and naming themes; and producing the report (87). The transcripts were independently screened by two of the researchers.

Ethics

Ethical approval for the research was granted by [Name and University]. CCEA facilitated access to the schools in Northern Ireland and the Republic of Ireland. The selection criteria of the participants was guided by the following considerations: teachers met regularly with CCEA to discuss curriculum and assessment issues; the participants were teachers of KS1 and KS2 maths; and had to be Irish speaking maths teachers working in IME schools. Active and voluntary consent was obtained by providing participant teachers and the principals of the schools with an information letter explaining the purpose of the research. The interview schedule was sent in advance of the interview.

Research findings

We present three key findings that emerged from our thematic analysis of the research: Language-as-deficit: Poor numeracy and language skills impede maths learning; language-as-a-resource impeded by the availability of Irish language teachers; and overcoming challenges to teaching maths in IME.

Language-as-deficit: poor numeracy and language skills impede maths learning

A number of key challenges emerged from the data, including the need, according to the teachers, for numeracy interventions, numeracy training and support for teachers (by which the teachers meant simply the ability to understand and work with numbers). All the teachers reported that there is little reinforcement of Irish language mathematical terms as these are not used outside of school hours. Teachers are also concerned about the level of maths preparation in Irish for post-primary transfer (post-primary education is secondary education in Northern Ireland) and whether this should be supported by teaching the concepts in English. However, many were averse to this idea. In addition, all the teachers expressed concern about consistency

in the use of mathematical terms in Irish as these can vary from one region to another across Northern and the Republic of Ireland, and which result from not having an agreed language framework. All the teachers in Northern Ireland reported that there were very few resources to support the development of children's numeracy skills and knowledge, as exemplified by this teacher:

> There's no support for numeracy of children who have numeracy difficulties. Teachers are very often left to their own devices. There's nowhere to go to seek support beyond the confines of the school; there's no proper teachers. This is, in general, in English and in Irish. (Teacher 3)

A corollary to the challenges in developing numeracy was the challenge associated with developing Irish language and literacy skills. While the teachers used these terms interchangeably, their responses made clear that they meant students' skills in reading and writing, as well as the knowledge, experience and culture that comes as children interact with their peers and environment (school, home, play). There was a strong consensus among the teachers that children who struggle with language and literacy also struggle with mathematical concepts and understanding written problems, particularly if they come from monolingual homes (or homes where the first language is not English). According to Teacher 1:

> The problem is presented [when the maths problem is] written down and it's a language problem, so the first thing you've got to do is to do with the language. And if you haven't got that basis in language … then the language prevents you even getting to that second stage where it's really sort of mathematical thinking or solving the problem.

It was the teachers' views that children's grasp of mathematical talk and language was imperative when it came to problem solving. However, difficulties with language and grasping mathematical concepts were particularly evident when it came to problem solving:

> Problem solving is a big area that comes up all the time when we go to numeracy clusters … questions in worded form, this keeps coming up as an issue. Because you have two tasks: you have the task of reading and of understanding; and then you have the task of maths – 'what maths do I have to engage in to get this answer right? (Teacher 6)

The difficulty, one teacher observed, was that it was 'the maths rather than the language' that was the problem, 'but the language for problem solving or for reading questions even is probably a language experience' (Teacher 1).

The challenge of teaching numeracy, language and literacy was compounded by what teachers regarded as parents' insouciance with maths and numeracy skills. Parents dismiss children's difficulties with maths because it is socially acceptable to struggle in this area, whereas poor language and literacy is a source of concern (not being able to read or write well). Teachers reported that children who struggle with literacy face further disadvantages if their parents are not proficient in the Irish language:

> If you say 'your child's having difficulty in maths', they'll turn around and say, 'well, no wonder! I was crap at maths myself'. Nobody ever goes, if you say they're having difficulties with literacy, 'aww I'm crap at reading myself'. You know, it seems to be okay not to be good at maths. (Teacher 4)

Developing language-as a-resource impeded by the availability of qualified Irish speaking teachers

Interview participants were also worried about resources with respect to availability, time for teaching preparation, opportunities for personal development and overall adequacy in education and training for those entering the teaching profession, particularly in relation to the delivery of mathematical teaching. University and University College spaces are limited in Northern Ireland, and there are not enough qualified IME teachers who are specialists in Maths, Sciences, and other subjects. A further difficulty (and this connects to the problems of language-as-resource) is that Irish speakers, including speakers who acquired the language through IME, may only have a specialism to GCSE/A-level, or who have not had the opportunity to learn the literacy associated it with their subject specialism.

In terms of tangible resources, this teacher highlighted the inaptitude of available material:

> We do find that any of the online resources that are available in Irish are very, very basic, language-based ones for junior infants, so, learning how to count or learning how to sort. There's very few as you go up, very few. (Teacher 10)

Inadequate training may be affecting teachers' confidence to teach maths which, consequently, may be transmitted to the pupils. Further, most teachers who enter IME are predominantly linguists (usually Irish, French or Spanish), which compounds the problem of teaching maths with confidence and skill:

> One thing that you'll maybe find in an Irish medium school that isn't in mainstream or English medium schools, is that everybody who works in the school will have a qualification in Irish … we would have very few teachers, I think, within the sector who have a mathematical qualification. (Teacher 4)

Generally, training opportunities for IME teachers, and in particular for maths, is limited due to the lack of courses provided in Irish, as every teacher in Northern Ireland frequently asserted. Even if there are courses available for CPD maths, schools struggle to attend them because there are few Irish-speaking teachers on the substitute register to cover the classes:

> … even is when there's been sub-cover there there's not much flexibility in the kind of pool of substitute teachers that are out there for the sector at the minute, so there's maybe four or five on our list, and if they're not available you just can't go on the course then. (Teacher 6)

Language-as-a-resource impeded by inequalities in resource provision

The research also reveals teachers' frustration with the lack of resources available to them to supplement their teaching of the subject in Irish, especially when compared to what is available for use in English medium schools. Additional resources are very limited so that many teachers use online English resources with the sound turned off. Each teacher reported that they collate their own resources to fill the resource gap, particularly with interactive and practical online resources. There is no equality in either the provision or quality of resources between the dominant and minority language education

sectors, which the teachers unanimously understood to be due to the minoritised status of Irish.

Teachers reported using a number of resources in order to teach maths through the medium of Irish, including textbooks, iPads, visualisers, interactive whiteboards and concrete learning materials such as counting blocks. Textbooks were described as useful resources but generally served as prompts that required further engagement in practice through active teaching with concrete materials:

> I'm not constantly making up problems if they're not reading problems from a book, that they can see them in a more visual way maybe, if they were kind of interactive games. (Teacher 5)

Teachers described using electronic devices on an individual basis as a useful resource, namely Ipads. However, the dearth of apps considered adequate for teaching maths through IME was described by several as a stumbling block, particularly with respect to workload and the burden associated with translating and adapting content from English to Irish:

> We're lucky in this school, I suppose, that we do have interactive boards in every room. We have iPads, but there's a limited amount you can do with this stuff because of the fact that we are an Irish speaking school and we're trying to teach mathematics through Irish. (Teacher 10)

Teachers made a number of suggestions to overcome existing challenges associated with teaching maths through IME. Suggestions centred around resource/capacity for parents to better support children in the home environment, improving teacher competence, increased training and adequate staffing to facilitate this, provision of resources that are both fit for purpose and adaptive, and an agreed framework to offer structure and guidance for teachers. Teacher competence and confidence, staff resources and increased competence in language were also reported as essential to overcoming existing challenges:

> Another challenge, maybe, is our own proficiency in numeracy, that if we don't feel confident in numeracy, then does that come across in the way that we teach? And on the flip side of that, if we're really proficient in numeracy do we understand the difficulties that the children have? (Teacher 3)

Alongside improving competence was the need for continuous professional development (CPD) and the capacity to facilitate CPD through provision of linguistically competent substitute staffing:

> Better training, initial teacher training, that they're prepared. I felt sometimes it was a lot of knowledge that we were being given rather than the practical steps to teaching numeracy in the classroom. (Teacher 3)

In terms of how to overcome challenges, teachers referred to provision of resources that were fit for purpose with capacity to adapt to a range of ages and abilities. Some staff highlighted the need for a structured language framework to offer guidance to schools, but which would only come into existence with an Irish Language Act:

> Well … some sort of language framework that could give you some sort of guidance generally … every single word is not going to be covered on a language framework, but if we could give schools a general idea that we were all following the same kind of plan – things get very complicated in P7 [primary], up at the top of the school. They are maybe not as complicated in English, you have a lot of words that would need to be moved into genitive cases … for the sentence to be grammatically correct. (Teacher 6)

With respect to suggestions for online resources in Irish, the teachers discussed the importance of language in learning mathematical concepts, with particular emphasis on problem solving. This kind of invisible reinforcement is not possible if English language resources must be resorted to:

> I think language, mathematical language, would have to be key to it … I don't think there's a point in having a game that's just numeracy based like, you know, two plus two equals … and you've to pick the number because there's billions of them available in English … something that was definitely re-enforcing the mathematical terminology, whilst also re-enforcing the concept. (Teacher 4)

Discussion

What the research here shows is that teachers are Irish enthusiasts, keenly aware of the difficulties of teaching maths in KS1/2 in IME but who do all they can to adapt whatever resources they do have to creatively teach maths. Among the key challenges are that resources in Irish are few, whether texts or interactive; children's mathematical competence is affected by poor numeracy and linguistic skills, problems that are compounded if their parents' language or mathematical skills are lacking, or teachers lack confidence in teaching maths. There are, in addition, few opportunities for CPD in Irish language development or maths teaching; and the profession is dominated by linguists, many of whom may not be confident or skilled in teaching maths.

As previous research has established, bilingualism can positively influence cognitive and linguistic development, and positively influence children's mathematical skills (for example, Ní Ríordáin and O' Donoghue 2009; Lauchlan, Parisi, and Fadda 2013; Hartanto, Yang, and Yang 2017; Purpura, Schmitt, and Ganley 2017). It is also very well established in the research literature that language is key to learning maths, and a key issue in the teaching of mathematics (Bialystok 2001; Ní Ríordáin and O' Donoghue 2009; Lauchlan, Parisi, and Fadda 2013; Hartanto, Yang, and Yang 2017; Ní Ríordáin 2018; Prediger 2019). However, the teachers who participated in this research reported that many of the teachers who come from teacher education courses are linguists, rarely mathematicians, which can impact on the competent teaching of maths in IME. Teachers need to be numerate as well as literate, they report, and which the research attests, and to have opportunities to receive on-going CPD in mathematical language skills and communication. Further, there is strong research evidence to show that fostering positive mathematical dispositions are vital to supporting mathematical understanding (Prediger 2019), which can have a significant impact on children's motivation to learn maths. Creative approaches to teaching maths, such as role play, story-telling, speculation, and outdoor learning, are essential (Setati 2005). Teachers are also aware, as Ní Ríordáin (2018) found in her own research, that speaking mathematically and peer discussion, are important. The problem is, however, that the quality and quantity of

resources, along with teachers' mathematical competence, impedes opportunities for language-as-resource, findings that are consonant with those of Ní Ríordáin (2018).

Researchers such as Ní Ríordáin and O' Donoghue (2009) have reported that cognisance of the importance of linguistic numeracy in teacher education programmes is critical, and that features of the language (syntax, concepts, number relation) may facilitate the teaching of maths in accordance with the idea of Irish-as-resource could be very helpful in this respect. Regarding Irish-as-resource, these researchers suggest, rather than Irish-as-deficit, Irish-as-resource may be critical to ongoing improvements in mathematical teaching, an approach that CCEA may find useful to explore further (Ní Ríordáin and O' Donoghue 2009; Planas and Civil 2013; Ní Ríordáin 2018). This means using the language as a communicative resource to encourage discussion, analysis, and problem-solving activities using predominantly Irish or English if resort to the L1 will enable quicker processing or access to the conceptual equivalent. However, there are risks with this orientation in that over reliance on English may mean fewer opportunities to use Irish, and resulting in fewer opportunities, therefore, to develop language resources that require abstract thinking and problem solving. The teachers in this study are acutely aware of these issues ('Gaelige-Bhriste' or broken Gaelig. Béarlachas also means that concepts from English are carried across and rendered into Irish phonology. For example, Fótasintéis, or photosynethsis, because the concept does not exist in the language or would require a lengthy translation).

Pre-school years are important to the development of children's literacy and numeracy, and it is well known that early academic skills are precursors for later academic success and school readiness (Purpura, Schmitt, and Ganley 2017). There is also research evidence which shows an association between early maths success and literacy: children who demonstrate difficulty in one area are likely to have difficulties in the other because certain aspects of literacy are foundational to the development of maths as is evidenced in problem-solving maths. The findings from this research support these claims. Participant teachers expressed concern that children who struggle with literacy also struggle with mathematical concepts and understanding written problems. Importantly, as the teachers reported here, children who have difficulties with numeracy need to have additional help on a par with the kind of help that is available to children who have difficulties with literacy. Research has demonstrated that high literacy levels and fluency in one-language clearly benefit literacy and fluency in the other.

Limitations of the research

This is a small-scale study which includes the perceptions, experiences and suggestions of 11 teachers in six schools, four of which are located in a small but growing sector in Northern Ireland, where professionals tend to be known to each other. As we have reported here, while the pool of mathematics teachers in the primary sector is small, the views presented in this report cannot not be generalised to the Irish medium profession.

In addition, we did not observe how the participants taught maths; we relied on the accounts given by experienced teachers in interviews on quite specific questions. Despite these limitations, the participant teachers' views provide valuable insights into the challenges of teaching KS1/2 maths in Irish, and the kinds of resources they would

like to see developed to enhance the teaching of maths. Many of their perceptions and experiences accord with what research, in general, has already established.

Conclusion

The key findings of this research are that: language proficiency is integral to the teaching and learning of maths; creative, dynamic, and interactive resources in Irish are urgently desired by teachers; and opportunities for continuing professional development in maths pedagogy would be welcomed by the teachers in this study.

Learning to do maths is closely connected to acquiring fluency in the language of mathematics. This fluency includes, words, phrases, symbols and abbreviations, along with ways of thinking, speaking and writing that are specific to maths (literacy). As has been demonstrated here and in the research, learning to communicate mathematically is key to learning maths, and to learning maths in Irish. Although Irish is not the first language of many pupils who attend IME schools, or their parents, this lack need not impede either their progress in Irish language acquisition, or in maths, provided that teachers communicate mathematically and regard Irish as a resource, and support pupils' progress in these areas. With the teaching of any subject, how the subject is taught is critical. Creativity, imagination, and a positive disposition to teach the subject are critical. Maths can be taught merely as a set of procedures or be taught in ways that encourage pupils to articulate, share, discuss, argue, tell stories, reflect on and refine their understanding of mathematical puzzles and dilemmas. Good mathematical communication requires both approaches (and others besides such as a positive context for learning, for example), and it requires good linguistic competency.

Language is not just oral, written, and symbolic speech that entails cognitive and linguistic processes, and language acquisition; language is also fundamentally relational and socio-cultural: it is localised, social, and meaning-making – and produces identities: Irish speakers, bi-lingual learners, members of the Gaeltacht, or preservers of language and culture in contexts in which English has become the predominant language and threatens the existence of minority languages in the United Kingdom. Language is, in addition, the means by which we struggle for meaning, truth and power, how we assert ourselves, and construct and define others. The availability and quality of resources, whether a national language framework exists, and the legal and political status of the language, convey how valued a language is to those who aspire to learn to communicate in that language.

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