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National Centre for Excellence in Mathematics and Science Teaching and Learning

Out-of-Field Teaching in Post-Primary Mathematics Education:
An Analysis of the Irish Context.

A Research Report

By

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We would like to thank all those who contributed feedback in the initial design of and piloting of the principal and teacher questionnaires. This important phase helped us to develop and implement appropriate questionnaires and to gain the information we needed from principals and teachers on out-of-field teaching at post-primary education in Ireland.

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SUMMARY OF THE STUDY

Introduction

Widespread coverage in the national media has highlighted the underperformance of post-primary students in mathematics and the low uptake of Higher Level mathematics at Senior Cycle education (EGFSN, 2008). In particular, performance in the Leaving Certificate examinations has been subjected to scrutiny, with growing concerns for the number of students failing Ordinary Level mathematics, and thus restricting their opportunities for further education and training. The Task Force on Physical Sciences (2002) reiterate this serious concern about the mathematical competence of second level students in Ireland and that high failure rates contribute to low intakes of students into the Science, Engineering and Technology subjects at third level education. Data on trends in technical, scientific and business occupations support an impression of a population ill-prepared to meet the needs of a growing knowledge economy requiring graduates with mathematical, scientific and ICT skills (EGFSN, 2008). However, little research has been undertaken to investigate issues of causality in relation to the decline in mathematics in Irish post-primary education.

Aim of the Study

Teacher quality is believed to be one of the most important factors affecting student learning. Research has demonstrated that students learn more from teachers who are skilled, experienced, and know what and how to teach (Darling-Hammond, 2000; Darling-Hammond & Youngs, 2002; Goldhaber, 2002; Rice, 2003; Wayne & Youngs, 2003). The aim of this study is to investigate the level of out-of-field teaching occurring in Irish post-primary mathematics classrooms, its potential influence on mathematics learning and to determine characteristics specific to the Irish context.

Out-of-Field Teaching Definition

The definition of out-of-field teaching employed in this study is that of 'teachers assigned by school administrators to teach subjects which do not match their training or education' (Ingersoll, 2002, p.5). These teachers generally possess a teaching qualification but will have little or no training or education in the area of mathematics education. The Teaching Council of Ireland has been established since 2006 in order to promote teaching as a profession and to regulate standards within the profession. In order to teach mathematics in a post-primary school in Ireland, they stipulate that teachers must:

- Have studied Mathematics as a major subject in the degree extending over at least three years and of the order of 30% at a minimum of that period.
- Provide details of the degree course content to show that the breadth and depth of the syllabi undertaken are such as to ensure competence to teach Mathematics to the highest level in post-primary education.
- Provide explicit evidence of standards achieved in degree studies in Mathematics with at least an overall Pass result in the examinations in Mathematics.

(Teaching Council, 2009)

Methodology

This investigation is quantitative in nature. Two questionnaires were designed – one for the teachers of mathematics and one for the principal of each school. The questionnaire for the teachers was designed to assess each teacher's undergraduate and post-graduate qualifications, number of years teaching experience of mathematics and other subject areas, the year group(s) being taught mathematics by the teacher and level of mathematics (Higher, Ordinary, Foundation), and the number of students in each of the teacher's mathematics classes. The questionnaire for the principals sought to establish the principal's views on teacher qualification and factors influencing the assignment of teachers to the teaching of mathematics within their schools. The sampling frame for this study was a list of all 731 post primary schools in Ireland (Dept. of Education website, November 2008) with a targeted sample size of 400 mathematics teachers giving a margin of error for the estimate of the percentage of unqualified mathematics teachers of ±5%, with a 95% confidence level. Using an estimate of an average of seven mathematics teachers in each school, a stratified random sample of 60 schools was selected.

Key Findings – Teacher Questionnaires

- The teachers taught an average of 10 hours of mathematics a week with a range of 1 to 22 hours. 25% of teachers taught less than 7 hours of mathematics a week.
- The most popular subjects for the teachers to teach with mathematics were science (33%), Business Studies (18%), Biology (15%), Resource (14%), Chemistry (13%), CSPE or SPHE (13%), ICT (12%), Physics (11%) and Accounting (11%).
- 48% of the teachers did not have a mathematics teaching qualification.
- Of the 156 (48%) of teachers without a mathematics teaching qualification, 35% had a BSc. primary degree (without a significant mathematics component), 34% had a B. Commerce /Business primary degree (without a significant mathematics component) and 27% had a concurrent teacher education degree without mathematics (e.g. science teachers graduating from the University of Limerick).
- Of the 168 teachers with a mathematics teaching qualification, 73% had a BA/BSc. with maths primary degree, 14% had a concurrent teacher education degree with maths and 11% had a BSc. primary degree with a significant amount of mathematics studied throughout the degree.
- In total, teachers without a teaching qualification in mathematics were teaching 6,294 students in the 51 schools compared to 14,579 students who were taught by teachers with a teaching qualification in mathematics. The total number of students taught by the teachers who responded to the survey in the 51 schools was 20,873 students. According to the Department of Education website there are 26,634 students in the 51 schools so the teachers who responded teach 78% of students in those schools. 22% of the students in the schools are, therefore, taught by the teachers who did not respond to the survey.
- Qualified mathematics teachers are primarily assigned to Higher and Ordinary Level mathematics classes, and particularly the examination years. Out-of-field teachers for the most part are assigned Ordinary Level (non-exam years in particular), Foundation, LCA (Leaving Certificate Applied) and resource teaching hours.
- Older teachers tended to be more likely to have a teaching qualification in mathematics. Only 40% of the teachers aged 35 or under had a teaching qualification in mathematics compared to 65% of the teachers aged over 35.

Key Findings – Principal Questionnaires

- 84% of the principals had 20 or more years of teaching experience with 36% of them having 10 or more years experience as a principal.
- Principals place the strongest emphasis on teacher qualification affecting their assignment of teachers to teach mathematics in their schools, with availability of teachers, teacher experience, and level of mathematics also having a significant influence on the assignment of teachers.
- Specialist mathematics teachers were asked by principals to teach all years at post-primary but particularly at examination year in the Junior Cycle (third year) and at Senior Cycle.
- First and second year were the most likely years for non-specialist teachers to be asked to teach mathematics by principals.
- 13 (52%) of the principals stated that they found it difficult to source suitably qualified mathematics teachers.
- 23 (92%) of the 25 agreed or strongly agreed with the statement that suitably qualified mathematics teachers were essential for long-term improvements in mathematics at post-primary education.

Recommendations

- Place greater emphasis on employing teachers specifically qualified to teach mathematics across all levels (Higher, Ordinary, and Foundation) and years (1st through 6th year) and enforce policy in this regard.
- Introduce postgraduate qualifications in mathematics and in mathematics education in order to provide opportunities for in- and out-of-field teachers to upgrade skills and achieve qualification to teach mathematics.
- Develop a coherent national policy for improving mathematics teacher quality and qualification.
- Encourage school principals/management to deploy teachers to subjects that they are specifically qualified to teach e.g. mathematics to redress the imbalance.
- Encourage school principals/management to work to redress the imbalance between the allocation of experienced mathematics teachers in exam and non-exam years, and between Junior and Senior Cycle.
- Launch a recruitment drive in order to attract mathematics graduates into the mathematics teaching profession and accordingly improve the availability of suitably qualified mathematics teachers at post-primary education.
- The phenomenon of out-of-field teachers of mathematics who are otherwise qualified post-primary teachers is a systemic problem that should be addressed by the Teaching Council in the context of its brief to regulate the teaching profession including mathematics teachers.
- In the case of rural or small schools principals might consider sharing teachers with a qualification in mathematics.
- Immediate support for out-of-field teachers should be provided in the in the form of, for example, resources, mathematics and teaching aids. These could be distributed to the schools and follow-up courses run for these teachers through a variety of delivery modes.
- School principals should receive school-based management training in managing the tradeoffs between organizational and educational needs in order to promote a better deployment of the mathematics teaching resource.

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ABSTRACT

Widespread coverage in the national media has highlighted the underperformance of Irish post-primary students in mathematics. However, little research has been undertaken to investigate issues of causality in relation to this decline. Smith (2004) emphasises that an adequate supply of suitably qualified mathematics teachers is an essential prerequisite for delivering long term improvements in post-primary mathematics education. Thus, the aim of this study is to investigate the level of out-of-field teaching occurring in Irish post-primary mathematics classrooms and to assess the type of post-primary schools in which this is dominant. The sampling frame consisted of a list of all 731 post-primary schools in Ireland (Department of Education and Science, website, November 2008). 12.5% of these schools are community/ comprehensive schools, 34.5% are vocational schools and the remaining 53.2% are secondary schools. A stratified random sample of 60 schools was selected so that the sample of 60 has approximately the same proportions of the different types of schools as the population. There are 30,000 students in the schools selected. 51 schools responded with 324 teachers of mathematics completing the questionnaire. There are 26,634 students in the schools who responded. Of the 60 principals of the schools, 25 (42%) returned their separate questionnaire. They were asked how many teachers of mathematics were in their school and the number given by them was compared to the number of teachers who responded separately from the same school. The 25 principals who responded stated that there were 164 teachers of mathematics in their schools, 94 (57%) of whom were "specialist" (this term was used to define 'qualified' for the principals in their questionnaire) mathematics teachers. The number of teachers of mathematics who responded from these schools was 128 (78% of the 164). Therefore, 78% is an estimate of the response rate of teachers of mathematics within schools. It is reasonable to assume that teachers with a teaching qualification in mathematics are more likely to respond than non-qualified teachers so the results from this survey may underestimate the percentage of teachers without a teaching qualification in mathematics. Findings on out-of-field mathematics teaching in the Irish context are presented and discussed.

PREFACE

It is well known, and widely reported in the media and elsewhere, that Ireland has a significant 'mathematics problem'. This, coupled with similar and associated problems in science education, is seen to impact negatively on the country's ability to progress towards a 'smart economy' which is the goal of current government economic and educational policy. Thankfully, the government, through the DES and other departments and agencies, have prioritised initiatives in this area and have launched the most ambitious programme yet in mathematics education, Project Maths, while supporting in tandem other activities in Science and Engineering including the National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL).

The mathematics problem is multi-dimensional and multi-faceted. However, there is general agreement that the quality of mathematics teaching in post-primary schools is an important factor in the teacher dimension of the problem, and that this needs urgent attention.

This report was conceived by Dr Máire Ní Ríordáin, Senior Projects Officer in Teaching and Learning (Mathematics), NCE-MSTL, to fill a gap in our understanding of the teacher dimension of the mathematics problem in Ireland by adding evidence-based research analyses to what has been largely soft or anecdotal evidence to date. The authors, Drs. Ní Ríordáin and Hannigan, have combined to produce an excellent report that significantly improves our understanding of one facet of the mathematics teacher dimension viz. the quality of mathematics teaching in post-primary schools.

The report provides a wealth of hard-to-get data that sheds considerable light on aspects of mathematics teaching in Ireland. On the basis of their data, the authors show clearly that one reason for the poor quality of mathematics teaching is the high proportion of teachers of mathematics (48%) in our post-primary schools that have no qualification in mathematics teaching. The negative impact of these teachers is accentuated by their concentrated deployment in the early years of Junior Cycle where students' attitudes and abilities need to be nurtured.

The authors are careful to offer a balanced view by adding international comparative data showing that Ireland is just one of many countries experiencing similar problems. The phenomenon of out-of-field teachers of mathematics, who are otherwise qualified post-primary teachers, is a systemic problem that is attributable to the operation of an 'open teachers' register' since before the foundation of the State.

The Directors, who approved the original project proposal, commend this report to all who have a stake in Irish education and particularly to those front-line agencies involved in improving Mathematics and Science teaching at all levels. We see it as the first of a number of reports, which will be produced by the National Centre as it pursues its brief to advise on matters related to Science and Mathematics teaching.

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INTRODUCTION

Widespread coverage in the national media has highlighted the underperformance of post-primary students in mathematics and the low uptake of Higher Level mathematics at Senior Cycle education (EGFSN, 2008). In particular, performance in the Leaving Certificate examinations has been subjected to scrutiny, with growing concerns for the number of students failing Ordinary Level mathematics, and thus restricting their opportunities for further education and training. The Task Force on Physical Sciences (2002) reiterate this serious concern about the mathematical competence of second level students in Ireland and that high failure rates contribute to low intakes of students into the Science, Engineering and Technology subjects at third level education. However, little research has been undertaken to investigate issues of causality in relation to the decline in mathematics in Irish post-primary education. Attention to this problem has been induced by developing social and economic issues. There is a belief that Ireland's ability to compete in a more technological global economy depends in part on the creation of a more substantial, well-trained scientific work force, as well as the general education of a more scientifically literate population, with mathematics underpinning the key disciplines of science, technology, business and finance (EGFSN, 2008). There is also the growing belief that this can be brought about through educational improvements in Irish schools, which is largely dependant upon the calibre of the teaching force and curricular content (EGFSN, 2008; NCCA, 2006).

The authors propose that out-of-field teaching may be one of the key influences on students' poor performance in mathematics at post-primary education in Ireland, and may explain the low uptake of the subject at Higher Level. Smith (2004) emphasises that an adequate supply of suitably qualified mathematics teachers is an essential prerequisite for delivering long term improvements in post-primary mathematics education. This research seeks to establish if there is a need to address and improve teacher qualifications in order to improve mathematics education at post-primary level in Ireland. Few sources of data on teacher qualifications exist in Ireland that could be analysed to verify, contest, or exemplify many of the suspected problems. This shortcoming in data availability/analysis hinders the development of educational policies that are dependant upon information about the sources of problems, their nature and potential solutions (Darling-Hammond, Berry & Thoreson, 2001). Thus, this study and data collection will provide the first insight into the potential role that suitably qualified mathematics teachers play in Irish post-primary mathematics education.

The purpose of this research is not to assign blame but rather to establish a factual basis for further research and teacher training to be undertaken in mathematics education in Ireland. We recognise current teachers as key stakeholders in the future of our mathematics education system and that there is a need to establish best practices and training as required by our current teaching force. In order to address issues of concern to our teachers and schools nationally, it is necessary to undertake a representative statistical analysis of the situation that currently exists in Ireland, while also drawing on international findings to underpin recommendations and conclusions. Teaching as a profession is a relatively new phenomenon in Ireland with the Teaching Council only in operation since 2006. Prior to this teaching at second level was operated on an 'open teachers' register' since before the foundation of the state, and this contributes to systemic issues concerning the deployment of teachers at local level. Therefore, the priority of this report is to establish the level of out-of-field teaching occurring in mathematics at second level education in Ireland, and address the training and professional needs of these valuable teachers in our education system.

AIM OF THE STUDY

Teacher quality is believed to be one of the most important factors affecting student learning. Research has demonstrated that students learn more from teachers who are skilled, experienced, and know what and how to teach (Darling-Hammond, 2000; Darling-Hammond & Youngs, 2002; Goldhaber, 2002; Rice, 2003; Wayne & Youngs, 2003). Knowledge of the subject matter (mathematics major) and knowledge of how to teach the subject (mathematics pedagogy/education) are perceived as the key components for successful mathematics teaching (Darling-Hammond & Hudson, 1990). Influential international organisations such as the OECD (2004, 2005) and UNESCO (2006) have highlighted the relationship between teacher quality and qualification as essential for effective mathematics teaching. The aim of this study is to investigate the level of out-of-field teaching occurring in Irish post-primary mathematics classrooms, its potential influence on mathematics learning and to determine characteristics specific to the Irish context.

OBJECTIVES

The key objectives of this research are:

- To fully understand and measure the problem of unqualified mathematics teachers in post-primary schools in Ireland.
- To assess the level (level of mathematics/ year groups) and the number of students affected by out-of-field mathematics teaching in Ireland.
- To examine the characteristics of the schools within which out-of-field mathematics teachers work and the role that Principals play in assigning teachers to teach mathematics.
- To produce a report on this representative national study for distribution by the NCE-MSTL.

THE IRISH CONTEXT

Data on trends in technical, scientific and business occupations support an impression of a population ill-prepared to meet the needs of a growing knowledge economy requiring graduates with mathematical, scientific and ICT skills (EGFSN, 2008).While occupational needs in these fields have increased significantly over the past two decades, fewer students are opting for Higher Level science and mathematics subjects at Senior Cycle post-primary education and accordingly at third level education in Ireland. Mathematical proficiency underpins many other disciplines such as science, business, technology, etc. and a recent report published by the Expert Group on Future Skills Needs (EGFSN, 2008) emphasises the importance of a national strategic approach to raising national mathematical achievement, similar to initiatives undertaken in the United States (U.S. National Mathematical Advisory Panel, 2008). This is not surprising when one looks at the progress of post-primary students in Ireland. Most recent data on post-primary mathematics education demonstrates that 43% of students sat mathematics at higher-level at Junior Certificate level in 2008. However, only 17% took mathematics at higher-level at Leaving Certificate level in 2008 (EGFSN, 2008). This is a significant drop in numbers between Junior and Senior Cycle mathematics education and well below the recommended estimates of 60% at Junior Certificate higher-level and 25% at Leaving Certificate higher-level (NCCA, 2005). Also of concern is the number of students failing mathematics at Leaving Certificate level – 5,000 students in 2008. This comprises 12% of the students taking mathematics at Leaving Certificate ordinary level. Accordingly their opportunity for further education and training are limited. International achievement comparisons are also discouraging. Ireland's performance on the PISA mathematics assessment (2006) saw us ranked 16th out of the 30 participating OECD countries. Fewer Irish students (10% compared to OECD average of 13%) achieved the highest proficiency level in comparison to more than 20% of students in the high performing countries such as Finland, South Korea, and Switzerland. 16% of Irish students achieved the lowest proficiency level in comparison to 6% of Finish students, although the OECD average was 21% (Educational Research Centre, 2007). However, these results should be interpreted with caution given differences in mathematics curricula and pedagogy, as well as differences in the average number of hours spent on mathematics instruction within participating countries.

Clearly there is a need to address the underperformance of Irish students in mathematics at post-primary education in Ireland. The researchers propose that one of the significant causes of this underperformance in mathematics at post-primary education may be attributed to out-of-field teaching in mathematics occurring at this level of education in Ireland. This refers to teachers assigned to teach subjects for which they are not qualified to do so (Ingersoll, 2002). Unless teachers are formally prepared to teach mathematics at post-primary education, it may have detrimental consequences for student learning and understanding (Darling-Hammond & Hudson, 1990). No Irish study in this area of research has been undertaken prior to this and the findings emerging from this work should provide significant insights into a possible explanation for our students' underperformance in mathematics at post-primary education, and accordingly the lack of uptake of mathematics and related courses of study at third level education.

OUT-OF-FIELD TEACHING-DEFINITION

When researching the problem of out-of-field teaching, difficulty lies in determining what standard to define a qualified mathematics teacher by. Empirical findings support the proposition that teacher qualification is related to student achievement and thus it is important to investigate this in the Irish context (Greenwald, Hedges & Laine, 1996; Ingersoll, 2002). The definition of out-of-field teaching employed in this study is that of 'teachers assigned by school administrators to teach subjects which do not match their training or education' (Ingersoll, 2002, p.5). These teachers generally possess a teaching qualification but will have little or no training or education in the area of mathematics education. The Teaching Council of Ireland has been established since 2006 in order to promote teaching as a profession and to regulate standards within the profession. In order to teach mathematics in a post-primary school in Ireland, they stipulate that teachers must:

- Have studied Mathematics as a major subject in the degree extending over at least three years and of the order of 30% at a minimum of that period.
- Provide details of the degree course content to show that the breadth and depth of the syllabi undertaken are such as to ensure competence to teach Mathematics to the highest level in post-primary education.
- Provide explicit evidence of standards achieved in degree studies in Mathematics with at least an overall Pass result in the examinations in Mathematics.

(Teaching Council, 2009)

However, this may not be enforced by school principals. For example in the Irish context many qualified science teachers are employed to teach mathematics to Junior Cycle level but their degree/post-graduate studies does not contain sufficient mathematics, mathematics pedagogy, or explicit instruction and training on how to teach mathematics. Current international research advocates that one of the causes of inadequate student achievement in mathematics is the failure of schools to assign suitably qualified teachers to appropriate subject areas relevant to their undergraduate and post-graduate qualifications (Darling-Hammond, 1999; Elmore & Fuhrman, 1995; Haycock, 1998; National Commission on Excellence in Education, 1983). The Chief Inspector's report in the UK (2001/'02) found that the quality of mathematics teaching is suffering in many schools due to the limited number of specialist mathematics teachers whose expertise is usually assigned to A-level courses (Higher Level Senior Cycle mathematics in Ireland is the nearest equivalent to A-level). As a consequence in the UK, non-specialist mathematics teachers are assigned to Key Stages 3 and 4 (equivalent to Junior Cycle in Ireland), where they often fail to respond to students' mathematical learning needs. Consequently, this state of affairs is having an adverse effect on students' performance in mathematics in England.

RELEVANT LITERATURE

The following sections will present relevant literature on teacher qualification; effectiveness in mathematics teaching and student achievement; international comparisons on out-of-field teaching in mathematics; and other school factors that impact on the occurrence of out-of-field teaching in mathematics.

Qualification, Effective Mathematics Teaching and Mathematics Achievement

Research on the nature of teaching establishes teaching as highly intricate and requiring extensive knowledge and a broad range of skills, flexibility, versatility, and commitment (Darling-Hammond & Hudson, 1990). Therefore to be an effective mathematics teacher one requires formal training in that field. Knowledge of the subject matter (mathematics) and knowledge of how to teach (mathematics pedagogy) are two general types of knowledge perceived as being required for successful teaching (Darling-Hammond & Hudson, 1990). In a regular mathematics lesson, a teacher must have knowledge of the content of the lesson and understand how to teach that content, how to modify and adapt according to student needs, while also being able to diagnose those needs (Darling-

Hammond & Hudson, 1990). To perceive that such skills can be obtained without formal preparation undermines and underestimates the complexity of the profession. Yet, out-of-field teachers continue to be assigned to teach mathematics at post-primary education in Ireland.

Teacher training (pre- and in-service) are central in influencing the quality of mathematics teaching (Chacko, 1989). The technical nature of mathematics and the intricate links within the mathematics syllabus can create problems for teachers whose understanding of mathematics is limited and accordingly affect their teaching of the topic (Borko, 1994). Effective mathematics teaching is by no means easily achieved but its importance is recognised throughout the literature. Defining effective mathematics teaching is complicated, even though an abundance of definitions exist. For example, Million (1987) classified effectiveness on lesson design and delivery method. The ability to demonstrate knowledge of the syllabus, to use a variety of teaching methods/approaches and to improve student achievement centre around Clark (1993) and Sullivan's (2001) definition of effectiveness. An Irish study undertaken by Smyth et al. (2006) on the experiences of 2nd year students (approx. 14 year olds) reveals significant insights into students' perceptions of effective teaching. The teacher's ability to explain the subject/topic to the students was the most cited important quality of effective teaching (Smyth et al., 2006). Clearly this cannot be achieved without sufficient subject matter knowledge and sufficient pedagogical knowledge of the topic. The work of Sanders and Rivers (1996) and Wenglinsky's (2000) affirms that teacher effectiveness is the single biggest contributor to student success. Successive years with an effective teacher(s) creates a significant educational advantage (Sanders, Wright & Horn, 1997). Failure in mathematics can therefore be attributed in part to poor mathematics teaching, which is influenced by teacher qualification.

A number of influential supra-national agencies (e.g. OECD, 2004, 2005; UNESCO Institute for Statistics, 2006) have associated teacher quality and access to qualified teachers as essential to economic development and social stability, thus highlighting this as a global issue. A study undertaken from 2002-2004 in 25 OECD countries reveals that there is a lack of highly qualified teachers in the mathematics and science subjects, as well as an unequal distribution of qualified teachers (OECD, 2005). Empirical research into the nature of teacher qualification and its relationship with student achievement purports that such a relationship is significant. For example Goldhaber and Brewer's (2000) study found that students achieve higher standards in mathematics when taught by certified mathematics teachers in comparison to students taught by uncertified teachers. Other studies using value-added student achievement data have concluded that student performance is more influenced by teacher qualification than other variables such as class size and composition (Sanders & Horn, 1994; Sanders & River 1996; Wright, Horn & Sanders, 1997). Ingersoll (2001) found that one-third of all secondary school mathematics teachers in America have neither a major nor a minor in mathematics or in such related disciplines as physics, engineering or mathematics education. The repercussions for student learning and poor performance in mathematics are not surprising given this finding. Ingersoll (2001) also found that newly hired teachers are more often assigned to teach subjects out of their field than more experienced teachers. Low-income public schools have more out-of-field teaching than schools in affluent communities do. Small schools have higher levels of out-of-field teaching. Junior high classes are more likely to be taught by out-of-field teachers than are senior high classes. There are also differences within schools: lower-achieving classes are more often taught by teachers without a degree in the field than are higher-achieving classes. Clearly unequal access to qualified mathematics teachers exists, and accordingly to quality mathematics teaching, and is detrimental to opportunities for learning and ultimately for educational outcomes (Ingersoll, 2002).

Darling-Hammond (2000) examined the comparative contributions of teacher qualifications, other school inputs, and student characteristics to student achievement across states in the US on the reading and mathematics assessments administered by NAEP (National Assessment of Educational Progress) in 1990, 1992, 1994, and 1996. The study found that teacher preparation and certification were the strongest predictors for student achievement in reading and mathematics. She also presents strong evidence for the influence of "well-qualified" teachers on student achievement in mathematics and reading. This was the most significant predictor of student achievement in her study. A well-qualified teacher possesses both a major in the subject being taught (e.g. mathematics) **and** a qualification to specifically teach that subject (e.g. certification to teach mathematics). The study concludes (online, no page numbers):

> *"The strength of the "well-qualified teacher" variable may be partly due to the fact it is proxy for both strong disciplinary knowledge (a major in the field taught) and substantial knowledge of education (full certification). If the two kinds of knowledge are interdependent as suggested in much of the literature, it makes sense that this variable would be more powerful than either subject matter knowledge or teaching knowledge alone."*

However, no empirical research investigating the inadequacies and disparities in access to qualified mathematics teachers, in particular using nationally representative data, has been undertaken in the Irish context. It is anticipated that similar results to that emerging from the literature will be evident in Irish post-primary schools.

Some International Comparative Data

To undertake a comparative examination of mathematics teacher quality across a number of countries is difficult. Each country will define a *qualified mathematics teacher* differently, along with the consideration that different mathematics curricula exist at post-primary education throughout the world. However, Akiba et al. (2007, p.372) propose using 'measurable characteristics' of effective mathematics teaching that research studies have demonstrated to be linked to student achievement. These are (a) full certification, (b) mathematics major, (c) mathematics education major, and (d) teaching experience of 3 or more years (Akiba et al., 2007). Table 1 provides a summary of descriptive statistics on teacher quality of 46 countries surveyed internationally (as in Akiba et al., 2007). Caution needs to be taken when interpreting the findings as the number of teachers of mathematics surveyed from each country varies (e.g. England n = 86 and USA: n = 328) so the data may not be truly representative of each country. However, the table provides a comparison for results emerging from the study undertaken by the authors. Overall, the table demonstrates that for these 46 countries the mean percentage of teachers teaching mathematics with a major in mathematics is 36.1%; teaching mathematics with a major in mathematics education is 15.2%; teaching mathematics with a major in mathematics *and* mathematics education is 34.1%; and teaching mathematics without a major in mathematics or a major in mathematics education is 14.6%. Looking closer at some of the countries involved in the study, 58.5% of teachers in New Zealand are qualified to teach mathematics, 70.3% of teachers are qualified in the USA, 73.6% are qualified in Australia, 83% are qualified in England, whereas in Japan and Scotland 87.9% and 88.7% respectively are qualified to teach mathematics. Clearly, the issue of out-of-field teachers and teacher qualification in mathematics teaching at post-primary education is a global issue, not just one affecting Ireland.

APPENDIX A
Descriptive Statistics of Teacher Quality Variables at Teacher Level

	Certification			Math/Math Education Major				Teaching Experience				
Country	Total *n*	Certified %	Not Certified %	Total *n*	Math Major %	Math Education Major %	Both Majors %	No Major %	*n*	*M*	Minimum	Maximum	*SD*
Armenia	163	100.0	0.0	180	45.0	6.0	36.6	12.4	166	19.6	3	50	9.7
Australia	180	95.8	4.2	196	15.7	13.0	44.9	26.4	190	15.5	1	40	9.6
Bahrain	113	87.3	12.7	120	8.3	46.9	40.5	4.3	110	11.3	1	34	8.3
Flemish Belgium	–	–	–	229	94.7	–	–	5.3	229	17.8	1	43	11.1
Botswana	124	100.0	0.0	132	45.3	17.7	32.6	4.4	121	6.4	1	26	5.1
Bulgaria	157	100.0	0.0	171	15.6	1.1	79.7	3.5	166	20.3	1	41	8.6
Chile	171	92.7	7.3	191	31.9	9.3	19.4	39.4	189	21.8	1	46	10.7
Cyprus	–	–	–	130	75.7	1.3	21.5	1.4	128	11.6	1	36	9.7
Egypt	205	99.7	0.3	216	20.1	14.2	65.0	0.7	204	13.4	2	28	5.0
England	–	–	–	86	25.6	7.3	50.1	17.0	86	15.9	1	42	11.7
Estonia	137	94.5	5.5	143	27.3	14.3	51.0	7.4	147	22.2	1	50	12.5
Ghana	119	78.0	22.0	129	27.4	19.9	29.4	23.3	136	7.8	1	33	7.0
Hong Kong	115	81.6	18.4	129	19.1	13.4	42.1	25.3	126	11.8	1	35	9.0
Hungary	–	–	–	151	5.9	57.3	33.9	2.9	148	21.9	1	46	9.9
Indonesia	149	100.0	0.0	148	12.6	34.9	44.8	7.7	142	13.2	1	29	6.9
Iran	142	85.1	14.9	175	57.2	10.3	21.4	11.1	172	14.0	1	36	8.0
Israel	127	99.1	0.9	139	22.2	18.2	53.2	6.5	139	14.8	1	39	8.3
Italy	201	100.0	0.0	216	20.9	–	–	79.1	202	22.4	1	36	8.4
Japan	133	99.3	0.7	141	29.2	6.8	51.9	12.1	146	16.7	1	42	8.6
Jordan	107	97.8	2.2	139	66.7	22.0	6.0	5.3	139	10.4	1	37	7.7
Korea	136	98.7	1.3	139	33.0	54.3	8.0	4.8	136	12.8	1	32	7.7
Latvia	–	–	–	142	15.4	1.2	82.5	0.9	143	22.2	3	46	10.7
Lithuania	202	100.0	0.0	203	60.6	5.7	32.6	1.1	206	20.4	1	50	10.6
Macedonia	63	25.1	74.9	145	50.2	31.2	8.4	10.2	142	20.4	1	39	10.9
Malaysia	135	86.0	14.0	149	17.2	19.7	28.1	35.0	148	10.6	1	35	8.3
Moldova	130	91.4	8.6	129	51.6	5.9	36.7	5.8	129	26.0	1	50	10.5
Morocco	72	100.0	0.0	56	65.2	12.1	5.4	17.3	66	18.2	1	30	6.9
Netherlands	–	–	–	124	12.1	32.6	33.6	21.6	120	17.0	1	37	10.5
New Zealand	153	79.3	20.7	161	32.7	5.9	19.8	41.5	154	14.9	1	37	9.9
Norway	154	100.0	0.0	148	32.5	0.5	2.1	64.9	166	18.3	1	41	11.5
Palestine	105	88.5	11.5	141	46.7	32.8	4.5	16.0	131	9.9	1	36	8.0
Philippines	121	94.4	5.6	133	37.7	29.1	22.8	10.4	130	11.5	1	37	8.6
Romania	173	96.1	3.9	170	73.8	1.1	22.2	2.8	171	23.9	1	43	11.9
Russia	204	100.0	0.0	213	95.7	–	–	4.3	207	22.6	1	49	11.0
Saudi Arabia	146	97.3	2.7	149	34.0	6.7	59.3	0.0	146	9.5	1	38	8.1
Scotland	–	–	–	133	30.8	12.9	44.9	11.3	127	16.5	1	35	10.1
Serbia	158	89.4	10.6	163	37.9	2.2	56.1	3.8	163	21.6	1	45	12.1
Singapore	288	100.0	0.0	303	32.7	4.1	53.3	10.0	294	11.9	1	48	12.3
Slovak Republic	175	93.8	6.2	179	30.5	29.7	30.0	9.7	178	20.8	1	48	12.3
Slovenia	160	95.1	4.9	166	27.1	19.7	52.5	0.7	166	19.7	1	37	8.5
South Africa	197	50.5	49.5	221	38.8	12.3	29.1	19.8	219	11.3	1	36	7.3
Sweden	207	100.0	0.0	249	20.9	14.8	40.5	23.8	250	14.2	1	41	12.2
Syria	66	70.3	29.7	84	22.9	11.9	59.6	5.6	85	10.3	1	30	6.5
Taiwan	145	98.0	2.0	149	22.8	5.1	56.4	15.6	148	13.6	1	40	10.2
Tunisia	138	92.8	7.2	148	53.7	9.7	29.0	7.5	98	12.2	1	36	9.8
United States	316	95.1	4.9	328	17.5	24.7	28.2	29.7	332	14.3	1	50	10.2
M		91.1	8.9		36.1	15.2	34.1	14.6		15.9			

Note. *Flemish Belgium* refers to the Flemish-speaking population in Belgium. The data on certification are not available from Flemish Belgium, Cyprus, England, Hungary, Latvia, the Netherlands, or Scotland. The data on math education major are not available from Flemish Belgium, Italy, or Russia.

Table 1: Mathematics teachers' qualifications - an international comparison. (Akiba et al, 2007).

Taking a closer look at some other studies carried out internationally, Finnish students high achievement scores in the international PISA (2003, 2006) mathematical studies have attracted much attention. Finnish society places a high expectation on their education system, and accordingly this can only be met with an adequate supply of suitably qualified teachers. Many researchers have looked to the characteristics of the teacher education system in place in Finland in order to explain their performance in these comparative studies. Teacher education is university based and subject specialist teachers (i.e. mathematics teachers) and pre-service teachers are required to complete a master's degree in order to gain employment in post-primary education. Fulfilment of this master's degree requires the completion of a thesis, either in mathematics or in mathematics education (Bjorkqvist, 2005). Therefore, it normally takes a student 5 years to qualify as a mathematics teacher in Finland and to be employed in their education system. The findings from Finland suggest and provide support that suitably qualified teachers are necessary for student achievement in mathematics.

A Government-commissioned study on the deployment of second level mathematics and science teachers surveyed one in four maintained secondary schools in England (Moor et al., 2006). Findings concluded from information provided by mathematical departmental heads in the surveyed schools found that 76% of teachers were mathematics specialists (i.e. had a degree in mathematics or a degree incorporating some mathematics or had studied mathematics as part of initial teacher training). The remaining 24% were non-specialist mathematics teachers or teachers of other subjects (e.g. science, PE, business). Therefore a significant proportion of teachers of mathematics at post-primary education in England are out-of-field teachers. The deployment of the non-specialist mathematics teachers was also an issue of concern arising from the study undertaken. Schools with lower than average GCSE results had higher proportions of the unqualified teachers. Also within schools, at the upper second level education (AS/A2-level) a greater number of classes were taught by qualified mathematics teachers than in lower second level education (Key stages 3 and 4). Similarly, specialist mathematics teachers are most likely to be allocated to teach high ability groups. Non-specialist mathematics teachers were largely deployed at Key stages 3 and 4 and with the low ability groups at these stages (Moor et al., 2006).

There is no single definition of a "suitable qualification" to teach mathematics at second level education in Australia (Harris & Jensz, 2006). It is largely at the discretion of states and territories, and accordingly teacher qualifications vary. Also, the increase in the number of pathways of entry into the teaching profession has complicated the ability to measure teacher qualification (Harris & Jensz, 2006). An extensive study on the preparation of mathematics teachers in Australia utilised heads of mathematics departments' views on necessary levels of mathematics qualifications (e.g. mathematical study, mathematics pedagogical study) in order to assess teachers' qualifications at second level education in Australia (Harris & Jensz, 2006). Heads of mathematics departments were generally of the view that teachers of senior school (year levels 11 and/or 12) second level mathematics required the most extensive third level preparation in regards to both content knowledge and pedagogical knowledge. More than half believed that mathematics teachers at junior school (year levels 7 and/or 8) should have studied mathematics beyond first year at third level education (Harris & Jensz, 2006). The study found that one in five teachers of mathematics in Australia had not studied mathematics beyond first year at third level education and were assigned to junior and middle (year levels 9 and/or 10) school mathematics. 10% of surveyed teachers did not study any mathematics at third level education and were assigned to teach junior school mathematics. 74% of teachers of mathematics in senior school held a major in mathematics. Similarly, 83% of those teaching intermediate or advanced level senior mathematics held a major in mathematics. 17% of junior school teachers of mathematics had not studied mathematics teaching methods, yet this was considered essential by nearly all heads of mathematics departments (95% of heads of departments). The difference in teaching experience at each level of post-primary education is striking. Those who do not teach senior school mathematics have a median of 10 years teaching experience, compared to a median of 22 years for those who teach only senior school mathematics (Harris & Jensz, 2006).

Characteristics of mathematics teachers of Year 9 (lower second level) students in New Zealand who participated in the Third International Mathematics and Science Study (TIMSS -98/99) were analysed in relation to the students' achievement in the study (Chamberlain & Caygill, 2002). Just under half (49%) of New Zealand Year 9 students in this study were taught mathematics by teachers with a major in mathematics (or mathematics education) in their degree and a teaching qualification. In comparison to other international countries who participated in TIMSS-98/99, on average 73% of students were taught mathematics by teachers with a major in mathematics and a teaching qualification (Chamberlain & Caygill, 2002, see Table 2). This study also found that teachers' confidence in teaching mathematics was related to their academic preparation to teach mathematics, and had a significant influence on their students learning. 36% of these New Zealand students in this study were taught mathematics by teachers whose major area of study was in science. This is similar to the Irish context as Werry (1980) noted that in New Zealand, there is an expectation that teachers are able to teach in more than one area e.g. science and mathematics. This may still be of significance in New Zealand due to timetabling, school size, curriculum integration, etc. (Chamberlain & Caygill, 2002).

Selected Countries	% of students taught by teachers with major area of study in mathematics.	% of students taught by certified teachers with major area of study in mathematics
Australia	72	72
Canada	28	25
Chile	78	77
England s	90	85
Finland	75	68
Hungary	99	99
Japan	93	93
Korea, Rep. of	97	97
Malaysia	72	65
Netherlands r	91	87
New Zealand	51	49
Philippines	87	81
Singapore	84	84
South Africa	82	72
United States	61	*
International Mean	84	83

An 's' indicates teacher response data only available for 50 to 69% of students.
** As the United States did not collect information on certification of teachers, this figure only represent those teachers that had mathematics as a major area of study.*

Table 2: Teachers having both teacher certification and mathematics as a major area of study for New Zealand and selected countries in TIMSS-98/99. (Chamberlain & Caygill, 2002, p.61).

Other School Factors

This research project is investigating the level of out-of-field mathematics teaching occurring in the Irish context. However it is also necessary to examine the characteristics of the schools within which out-of-field teaching is occurring. The way in which schools are organised and the way in which teachers are assigned to teach classes can account for the problem of under qualified mathematics teachers, along with an insufficient supply and training (Ingersoll, 2002). Irish post-primary teachers have limited influence on school decision making. For example, they have little influence on what year groups and classes they teach. This responsibility is primarily the charge and privilege of school principals. Naturally principals encounter constraints too in the form of resources, budgets, providing a broad range of subjects, class sizes, etc., which has repercussions (and is often unavoidable) for the hiring and allocation of teachers to teach particular subjects (Ingersoll, 2002). Nevertheless, within these limitations, discretion in staffing decisions lies primarily with the school principals and there is inadequate regulation of how teachers are deployed once in a post-primary school (Ingersoll, 1999; Robinson, 1985). This needs to be addressed and examined from a mathematics perspective within the Irish context.

METHODOLOGY

This investigation is quantitative in nature. Two questionnaires were designed – one for the teachers of mathematics and one for the principal of each school. The questionnaire for the teachers was designed to assess each teacher's undergraduate and post-graduate qualifications, number of years teaching experience of mathematics and other subject areas, the year group(s) being taught mathematics by the teacher and level of mathematics (Higher, Ordinary, Foundation), and the number of students in each of the teacher's mathematics classes. A number of open ended questions were also included in order to examine the training/qualification needs of all teachers engaged in mathematics teaching in post-primary schools. The questionnaire for the principals examined the type of school (secondary school, vocational, community and comprehensive school) and specific characteristics (e.g. mixed/single-sex, number of mathematics teachers, etc.). This questionnaire sought to establish the principal's views on teacher qualification and factors influencing the assignment of teachers to the teaching of mathematics within their schools.

The sampling frame for this study was a list of all 731 post primary schools in Ireland (Dept. of Education website, November 2008). 12.5% of these schools are community schools, 34.3% are vocational schools and the remaining 53.2% are secondary schools. The targeted sample size was 400 mathematics teachers giving a margin of error for the estimate of the percentage of unqualified mathematics teachers of ±5%, with a 95% confidence level. Using an estimate of an average of seven mathematics teachers in each school, a stratified random sample of 60 schools was selected so that the sample of 60 has approximately the same proportions of the different types of schools as the population. There are 30,000 students in the schools selected. Each school represented a cluster of mathematics teachers.

Each of the principals of the 60 schools was sent a questionnaire to be completed and returned in a stamped addressed envelop. The principals were also sent the teacher questionnaires and were given the responsibility of distributing these questionnaires to the teachers teaching mathematics in the school. Each principal received 10 teacher questionnaires and 10 stamped addressed envelopes for the questionnaires to be returned in. Instructions for the principals stated that if more then 10 teachers were teaching mathematics in their schools then copies of the questionnaire should be made and more than one questionnaire could be returned in each of the envelopes. Each envelope was given a number corresponding to the schools selected so the researchers could identify the schools that had returned the completed questionnaires. Two weeks after sending the questionnaires, follow-up telephone calls to each of the principals of the schools that had not returned any questionnaires were undertaken so as to increase the response rate of the principal and teacher questionnaires.

Teachers from 51 schools (85% of the targeted sample) have responded to the survey. 324 questionnaires were returned from teachers teaching mathematics in these schools. There are 26,634 students in the schools who responded with a median of 463 students and a range of 69 to 1230 students in each school. The number of teachers who returned the questionnaire in each school ranged from 2 to 14 teachers with a median of 6 teachers. 25 (42%) of the 60 principals returned the separate principal questionnaire. They were asked how many teachers of mathematics were in their school and the number given by them was compared to the number of teachers who responded separately from the same school. The 25 principals who responded stated that there were 164 teachers of mathematics in their schools, 94 (57%) of whom were "specialist" mathematics teachers. The number of teachers of mathematics who responded from these schools was 128 (78% of the 164). Therefore, 78% is an estimate of the response rate of teachers of mathematics within schools. It is reasonable to assume that teachers with a teaching qualification in mathematics are more likely to respond than non-qualified teachers so the results from this survey may underestimate the percentage of teachers without a teaching qualification in mathematics.

51% of the teachers who responded taught in secondary schools, 35% in vocational schools and the remaining 14% in community schools. The percentage of each type of school in the sample is very similar to the national percentages. Two thirds of the teachers were full time teachers, a quarter of the teachers were full-time but only employed during the school year and 10% of the teachers worked part-time. 53% of the teachers were female. A bar chart of the age of the teachers is given in Figure 1. 71% of the teachers are aged 40 or under. Given the relatively young age of the teachers who replied to this survey, it suggests that there will be a need to develop continuous professional development strategies for this work force. 12 (48%) of the 25 principals who responded were from secondary schools, 9 (36%) from vocational schools and 4 (16%) from community schools. Three quarters of the principals were male and over half were aged 61 or older.

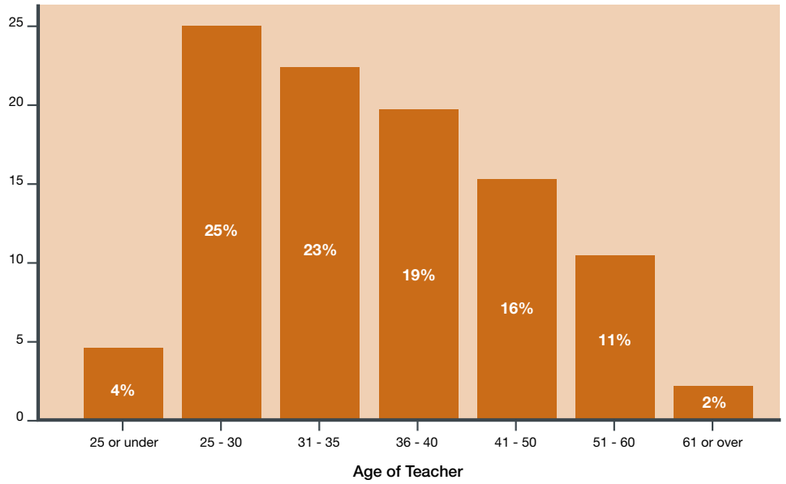

Figure 1: Percentage of teachers in each age category (n=324)

FINDINGS – TEACHER QUESTIONNAIRES

A statistical analysis of the data was undertaken using the statistical software package SPSS for Windows (Version 15) and the findings will be discussed in the following subsections.

Experience of Teaching Mathematics at Post-Primary Level

62% of the teachers had been teaching at post-primary for 10 or more years. A similar percentage had been teaching mathematics at post-primary for 10 or more years. A bar chart of the categories of years of experience teaching mathematics at post-primary level is provided in Figure 2.

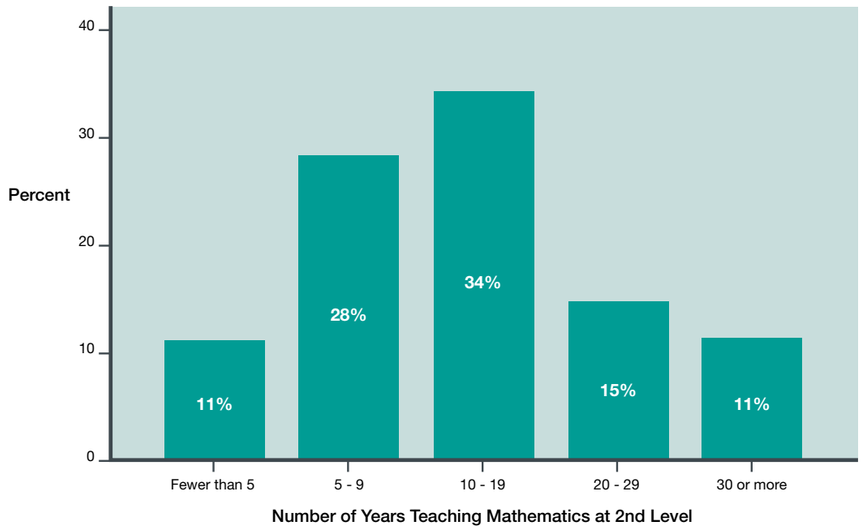

Figure 2: Bar chart of categories of years of experience teaching mathematics (n=324)

The teachers taught an average of 10 *hours* of mathematics a week with a range of 1 to 22 hours. 25% of teachers taught less than 7 hours of mathematics a week. The average number of mathematics *classes* (usually 35-40 minutes) taught by the teachers was 15 classes with a range of 2 to 36. 25% of teachers taught 10 classes or less of mathematics each week. The most popular subjects for the teachers to teach with mathematics were science (33%), Business Studies (18%), Biology (15%), Resource (14%), Chemistry (13%), CSPE or SPHE (13%), ICT (12%), Physics (11%) and Accounting (11%). All other subjects were taught by less than 10% of the teachers in the sample. 90% of the teachers said they enjoyed teaching mathematics at post-primary. Of those who gave further information on why they enjoyed teaching mathematics (n=153, 47% of the sample), 44% said they loved the subject and helping students, 27% said they enjoy when classes are motivated and 19% said it was challenging.

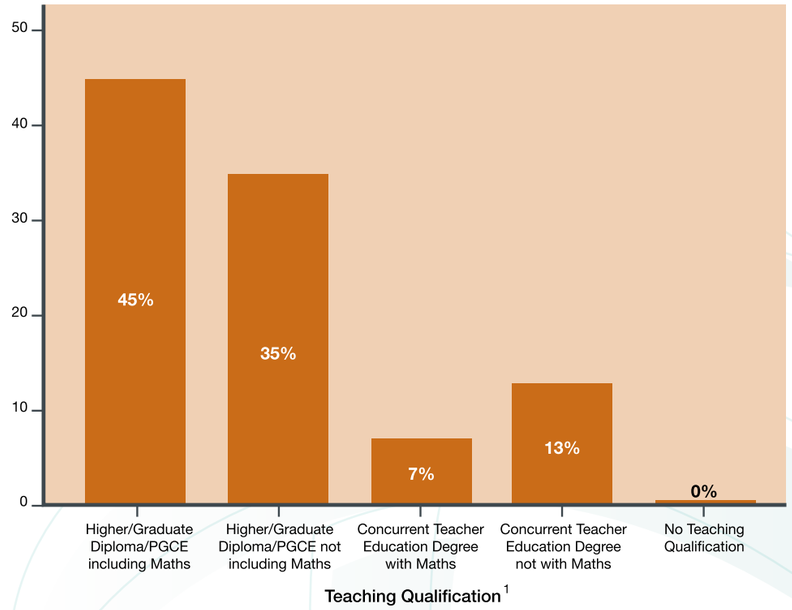

Figure 3: Bar chart of types of teaching qualification (n=324)

Only 1 of the 324 teachers did not have a teaching qualification though 48% of the teachers did not have a mathematics teaching qualification. A bar chart of the type of teaching qualification obtained by the teachers is given in Figure 3. Of the 156 (48%) of teachers without a mathematics teaching qualification, 35% had a BSc. primary degree (without a significant mathematics component), 34% had a B. Commerce /Business primary degree (without a significant mathematics component) and 27% had a concurrent teacher education degree without mathematics (e.g. science teachers graduating from the University of Limerick). Of the 168 teachers with a mathematics teaching qualification, 73% had a BA/BSc. with maths primary degree, 14% had a concurrent teacher education degree with maths and 11% had a BSc. primary degree with a significant amount of mathematics studied throughout the degree.

The highest qualification obtained by 18% of the teachers was a degree (58 of the 59 teachers in this category had a degree in concurrent teacher education courses). Almost two-thirds of the teachers had a Higher Diploma as well as their primary degree. The remaining 16% of teachers had a Grad Dip/Masters/PhD. Only 4% of the teachers were currently undertaking a further qualification.

[1] Higher/Graduate Diplomas in Education are awarded in Ireland. A Post Graduate Certificate in Education (PGCE) is awarded in the UK.

The teachers without a teaching qualification in mathematics taught an average of 7 hours of mathematics a week with a range of 1 to 15 hours. The teachers with a teaching qualification in mathematics taught an average of 14 hours of mathematics a week with a range of 1 to 22 hours. The average number of mathematics classes taught by teachers without a teaching qualification in mathematics was 15 classes with a range of 2 to 25. The average number of mathematics classes taught by teachers with a teaching qualification in mathematics was 21 classes with a range of 5 to 36. In total, teachers without a teaching qualification in mathematics said they were teaching 6,294 students in the 51 schools compared to 14,579 students who were taught by teachers with a teaching qualification in mathematics. The total number of students taught by the teachers who responded to the survey in the 51 schools was 20,873 students. According to the Department of Education and Science website there are 26,634 students in the 51 schools so the teachers who responded teach 78% of students in those schools. 22% of the students in the schools are, therefore, taught by the teachers who did not respond to the survey.

Overall, 78% of teachers felt that their qualifications were adequate for preparing them to teach mathematics at post-primary. All the teachers with a concurrent teacher education degree with mathematics (this is provided at the University of Limerick: Physical Education and Mathematics Teaching degree) felt their qualifications were adequate for preparing them to teach mathematics at post-primary compared to 46% of those with a concurrent teacher education degree without mathematics (Science/Materials & Construction/Materials & Engineering teachers). Table 3 summarises the percentage of those who felt their qualifications were adequate by type of teaching qualification.

	TYPE OF TEACHING QUALIFICATION				
Qualification adequate?	**H Dip/ Grad Dip/ PGCE with maths**	**H Dip/ Grad Dip/ PGCE without maths**	**Concurrent teacher education degree with maths**	**Concurrent teacher education degree without maths**	**None**
Yes	131 (90%)	79 (70%)	23 (100%)	19 (46%)	0 (0%)
No	14 (10%)	34 (30%)	0 (0%)	22 (54%)	1 (100%)

Table 3: Type of teaching qualification by whether the teachers felt it was adequate in preparing them to teach mathematics at post-primary

Over 90% of the teachers said that they would avail of continuous professional development (CPD) courses in mathematics if these courses were offered by the NCE-MSTL. Of the 219 teachers (68% of the total sample) who specified areas of CPD they were interested in, 45% were interested in courses in teaching methodology, 21% in Project Maths and 19% in ICT. 76% of the teachers without a teaching qualification in mathematics said they would avail of a qualification for teaching mathematics if one was provided by the NCE-MSTL. 28% of those who already have a teaching qualification in mathematics would also avail of a qualification from the NCE-MSTL.

In the following tables (Tables 4, 5, 6, 7 and 8) the percentages and number of qualified/unqualified teachers do not sum to 100%, due to the fact that teachers are assigned multiple classes and year groups e.g. a teacher could be teaching a first year, a third year and a fifth year group. Therefore they appear in the table for each year group and level that they are teaching.

The respective sample sizes are n=186 (qualified) and n=156 (unqualified). Table 4 summarises the years taught by the teachers in post-primary schools by whether or not they had a teaching qualification in mathematics. Teachers with a teaching qualification in mathematics are more likely to be teaching students in the examination year of the Junior Cycle (Third year) and in Senior Cycle. Teachers without a teaching qualification in mathematics are more likely to teach students in the Junior Cycle.

TEACHING QUAL. IN MATHS	YEAR OF STUDY					
	First	**Second**	**Third**	**Fourth**	**Fifth**	**Sixth**
Yes (n=168)	85 (51%)	100 (60%)	134 (80%)	95 (57%)	133 (79%)	131 (78%)
No (n=156)	81 (52%)	94 (60%)	79 (51%)	18 (12%)	45 (29%)	38 (24%)

Table 4: Numbers teaching in each year by whether or not they had a teaching qualification in mathematics (% of total in teaching qualification category).

Table 5, 6 and 7 summarises the level taught (higher, ordinary, foundation) in each year at post-primary by whether or not the teacher had a teaching qualification in mathematics. First year is not included because most first years are not streamed and fourth year (transition year) is also excluded due to inconsistencies in schools offering it and given that officially teachers are encouraged to teach alternative mathematics courses throughout this year.

TEACHING QUAL. IN MATHS	YEAR OF STUDY [HIGHER LEVEL]			
	Second	**Third**	**Fifth**	**Sixth**
Yes (n=168)	52 (31%)	71 (42%)	75 (45%)	68 (40%)
No (n=156)	7 (4.5%)	4 (3%)	0 (0%)	2 (1%)

Table 5: Numbers teaching at Higher Level in each year by whether or not they had a teaching qualification in mathematics (% of total in teaching qualification category).

The percentages in Table 5 demonstrate that teachers in this study with a teaching qualification in mathematics are distributed across the Higher Level year groups. Table 5 also clearly demonstrates that out-of-field teachers in this study rarely get assigned the Higher Level year groups.

TEACHING QUAL. IN MATHS	YEAR OF STUDY [ORDINARY LEVEL]			
	Second	**Third**	**Fifth**	**Sixth**
Yes (n=168)	38 (23%)	52 (31%)	54 (32%)	56 (33%)
No (n=156)	51 (33%)	37 (24%)	21 (13%)	26 (17%)

Table 6: Numbers teaching at Ordinary Level in each year by whether or not they had a teaching qualification in mathematics (% of total in teaching qualification category).

Table 6 demonstrates that out-of-field teachers in this study are assigned the Ordinary Level year groups, particularly at Junior Cycle. The percentages in Table 6 also demonstrate that fewer teachers in this study with a teaching qualification in mathematics are assigned Ordinary Level year groups compared to Higher Level year groups, particularly at Junior Cycle (as in Table 5).

The percentages in Table 7 demonstrate that Foundation Level mathematics at Junior Cycle and Leaving Certificate Applied (LCA) mathematics at Senior Cycle are primarily taught by out-of-field mathematics teachers in this study.

Teaching Qual. in maths	YEAR OF STUDY [Foundation Level and LCA]			
	Second	Third	Fifth	Sixth
Yes (n=168)	3 (2%)	2 (1%)	2 (1%)	4 (2%)
No (n=156)	9 (6%)	15 (10%)	19 (12%)	9 (6%)

Table 7: Numbers teaching at Foundation Level (and LCA[2] at Senior Cycle) in each year by whether or not they had a teaching qualification in mathematics (% of total in teaching qualification category).

Table 8 summarises the number of resource teachers teaching in the first three years of post-primary (the most common years for resource teaching) by whether or not they had a teaching qualification in mathematics. Again, it is evident that out-of-field mathematics teachers are primarily assigned these classes, in comparison to the qualified mathematics teachers in this study.

Teaching Qual. in maths	YEAR OF STUDY [Resource]		
	First	Second	Third
Yes (n=168)	2 (1%)	4 (2%)	1 (1%)
No (n=156)	11 (7%)	23 (15%)	12 (8%)

Table 8: Numbers of resource teachers in the first three years of post-primary by whether or not they had a teaching qualification in mathematics (% of total in teaching qualification category).

Clearly from Tables 5, 6, 7 and 8 it is evident that qualified mathematics teachers are principally assigned to Higher and Ordinary Level mathematics classes, and particularly the examination years. Out-of-field teachers for the most part are assigned Ordinary Level (non-exam years in particular), Foundation, LCA (Leaving Certificate Applied) and resource teaching hours.

Teacher and School Characteristics and Type of Teaching Qualification Obtained

There is no significant relationship between gender and whether or not the teacher had a teaching qualification in mathematics – 54% of the males had a relevant qualification compared to 50% of the females. However, older teachers tended to be more likely to have a teaching qualification in mathematics. Only 40% of the teachers aged 35 or under had a teaching qualification in mathematics compared to 65% of the teachers aged over 35. Table 9 examines the relationship between age and whether or not the teacher had a teaching qualification in mathematics.

	TEACHING QUALIFICATION IN MATHEMATICS?	
Age group	**Yes**	**No**
Under 25 (n=12)	4 (33%)	8 (67%)
25-30 (n=81)	31 (38%)	50 (62%)
31-35 (n=76)	33 (43%)	43 (57%)
36-40 (n=60)	34 (57%)	26 (43%)
41-50 (n=53)	41 (77%)	12 (23%)
51-60 (n=36)	22 (61%)	14 (39%)
61 or over (n=6)	3 (50%)	3 (50%)

Table 9: Numbers in each group by whether or not they had a teaching qualification in mathematics (% of total in age group).

[2] Leaving Certificate Applied programme offered at Senior Cycle education in Ireland. Alternative to the traditional Leaving Certificate programme. The majority of students taking Foundation level mathematics at Junior Cycle opt for the LCA programme at Senior Cycle.

There is no significant relationship between type of school and whether or not the teacher had a teaching qualification in mathematics though vocational schools tended to be slightly more likely to have qualified teachers. Care should be taken when interpreting that result because 5 (24%) of the 21 vocational schools, selected in the sample, did not respond compared to 3 (9%) of the 32 secondary schools selected and 1 (14%) of the 7 community or comprehensive schools selected. Table 10 examines the relationship between type of school and whether or not the teacher had a teaching qualification in mathematics.

	TEACHING QUALIFICATION IN MATHEMATICS?	
Type of school	**No**	**Yes**
Secondary (n=165)	83 (50%)	82 (50%)
Community or comprehensive (n=44)	23 (52%)	21 (48%)
Vocational (n=115)	50 (44%)	65 (56%)

Table 10: Numbers in each type of school by whether or not they had a teaching qualification in mathematics (% of total in school type).

Approximately a third of the schools that responded have fewer than 300 pupils, a third have 300-600 pupils and a third have greater than 600 pupils. Table 11 summarises the relationship between school size and whether or not the teacher had a teaching qualification in mathematics. Schools with less than 300 pupils tended to have fewer teachers with a teaching qualification in mathematics but there is no significant relationship between size of school and teacher qualifications.

	TEACHING QUALIFICATION IN MATHEMATICS?	
Size of school	**No**	**Yes**
< 300 pupils	34 (55%)	28 (45%)
300 -600 pupils	45 (44%)	58 (56%)
> 600 pupils	77 (48%)	82 (52%)

Table 11: Numbers in each size of school by whether or not they had a teaching qualification in mathematics (% of total in school size).

FINDINGS – PRINCIPALS' QUESTIONNAIRE

A statistical analysis of the data was undertaken using the statistical software package SPSS for Windows (Version 15) and the findings will be discussed in the following subsections.

Experience of Principals at Post-Primary Level

84% of the principals had 20 or more years of teaching experience with 36% of them having 10 or more years experience as a principal. Bar charts of the categories of years of experience teaching and being a principal are provided in Figures 4 and 5.

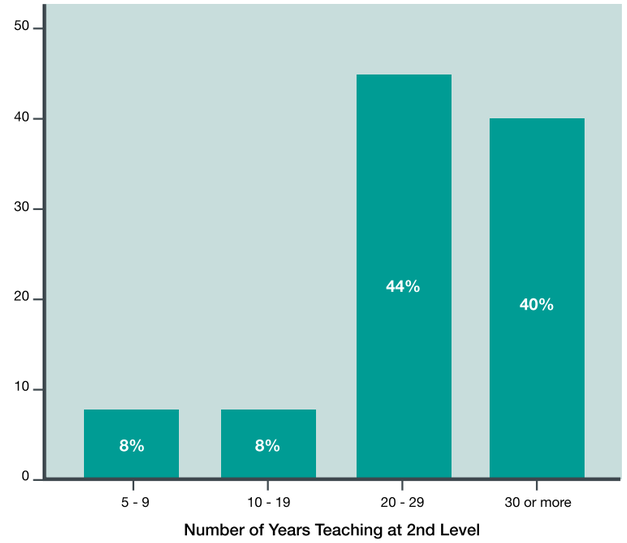

Figure 4: Bar chart of categories of years of experience teaching (n=25)

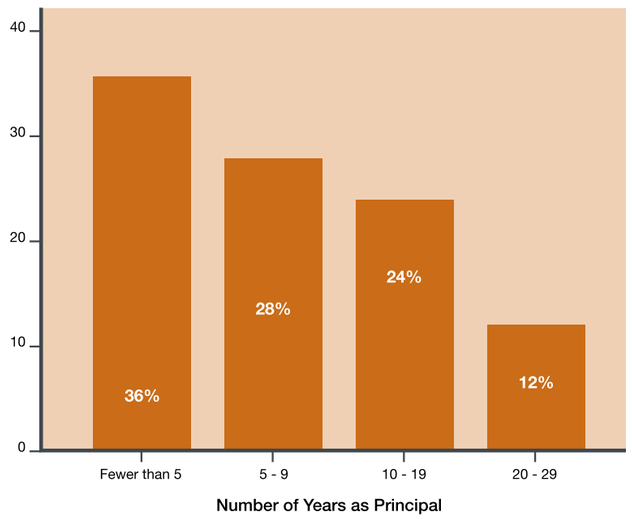

Figure 5: Bar chart of categories of years of experience as principal (n=25)

Qualifications of Principals at Post-Primary Level

The highest level of education for 12 (48%) of the principals was a Higher Diploma, 8 (32%) had a Masters degree, 3 (12%) had a Graduate Diploma, one had a PhD in Education and one had a primary degree only. None were pursuing further qualifications.

The principals were asked to rate the importance of various factors in their assignment of teachers to teach mathematics – Table 12 summarises their responses. Principals place the strongest emphasis on teacher qualification affecting their assignment of teachers to teach mathematics in their schools, with availability of teachers, teacher experience, and level of mathematics also having a significant influence on the assignment of teachers.

Factor affecting assignment?	Does not affect (1)	Slightly affects (2)	Neutral (3)	Affects (4)	Significantly affects (5)	Median (on a scale 1-5)
Teacher qualification	3 (12%)	1 (4%)	0 (0%)	4 (16%)	17 (68%)	5
Availability of teachers	1 (4%)	2 (8%)	8 (32%)	5 (20%)	9 (36%)	4
Timetabling	4 (16%)	5 (20%)	10 (50%)	4 (16%)	2 (8%)	3
Class group	5 (20%)	3 (12%)	6 (24%)	9 (36%)	2 (8%)	3
Teacher experience	2 (8%)	5 (20%)	4 (16%)	10 (40%)	4 (16%)	4
Level taught	2 (8%)	4 (16%)	6 (24%)	9 (36%)	4 (16%)	4
Availability of resources	19 (76%)	4 (16%)	0 (0%)	1 (4%)	1 (4%)	1

Table 12: Importance of factors to principals in the assignment of teachers to teach mathematics (n=25)

The principals (n=25) were asked what subject teachers had also been asked to teach mathematics in the school. The results are summarised in Table 13. Other subjects (apart from those in Table 13) were mentioned by less than 10% of principals.

Subject	Have taught mathematics in the school
Science	21 (84%)
Business studies	16 (64%)
Computer/ICT	8 (32%)
Engineering	6 (24%)
Languages	5 (20%)
Construction Studies	4 (16%)
Resource (non mathematics elective)	4 (16%)
Geography	3 (12%)

Table 13: Subject teachers asked by the principals (n=25) to teach mathematics in the school

Specialist mathematics teachers were asked by principals to teach all years at post-primary but particularly at examination year in the Junior Cycle (third year) and at Senior Cycle (Table 14). First and second year were the most likely years for non-specialist teachers to be asked to teach.

Type of teacher	Years Taught					
	First	Second	Third	Fourth	Fifth	Sixth
Specialist	20 (80%)	22 (88%)	25 (100%)	21 (84%)	25 (100%)	25 (100%)
Non-specialist	18 (72%)	17 (68%)	15 (60%)	12 (48%)	14 (56%)	13 (52%)

Table 14: Type of teacher and years taught at post-primary – information from principals (n=25)

13 (52%) of the principals stated that they found it difficult to source suitably qualified mathematics teachers. 23 (92%) of the 25 agreed or strongly agreed with the statement that suitably qualified mathematics teachers were essential for long-term improvements in mathematics at post-primary and 22 (88%) said they would encourage non-specialist mathematics teachers to avail of a mathematics qualification provided by the NCE-MSTL.

DISCUSSION

The findings presented here provide a possible explanation for the poor performance in mathematics of post-primary students in Ireland. Naturally, there are many other factors at play (e.g. attitudes, motivation, learning difficulties, etc.) but the authors strongly argue that specifically qualified mathematics teachers play a significant role in improving the quality of mathematics learning at post-primary level (Smith, 2004). One of the significant findings emerging from this research is that nearly half (48%) of the teachers teaching mathematics who responded to this questionnaire are not qualified mathematics teachers. The majority of these teachers are qualified science and business studies teachers and appear to be assigned mathematics classes, perhaps due to timetabling and staffing issues. The number of unqualified mathematics teachers is considerably lower than the estimated 80% as mentioned in the Royal Irish Academy report (2008), so this is positive in terms of the numbers requiring further training and staffing considerations. However, not all mathematics teachers in the selected schools responded to this survey. The teachers who responded from the 51 schools reported teaching 78% of the total numbers of students in these schools. 78% of the teachers responded from the 25 schools where the principals gave independent information on the number of mathematics teachers in the school. The 25 principals' data on the number of specifically qualified mathematics teachers in their schools suggests that the majority of these teachers in their schools responded to the questionnaire. Therefore, it is reasonable to assume that teachers with a teaching qualification in mathematics are more likely to respond than non-qualified teachers so the results from this survey may underestimate the percentage of teachers without a teaching qualification in mathematics. However, as the literature review demonstrates, the issue of out-of-field teaching in mathematics is a global one with varying levels of out-of-field teaching evident across countries (e.g. Akiba et al, 2007; OECD, 2004, 2005). Therefore, Ireland is not unique in this regard but this study provides us with statistical information that can be utilized to develop CPD measures to improve the situation in our post-primary schools.

There is no doubt that a significant number of post-primary students in Irish post-primary schools are being taught mathematics by out-of-field teachers (unqualified mathematics teachers). This is particularly evident at the Junior Cycle level, during the first and second years of study. There is also cause for concern that a considerable number (63%) of these out-of-field teachers who responded feel that they are 'suitably qualified' to teach mathematics even though their degrees and postgraduate qualifications do not contain sufficient mathematics nor a qualification to teach the subject. The out-of-field teachers who had pursued a concurrent teacher education degree (e.g. science education) were more conscious of their inadequacies to teach mathematics, which may be reflective of the type of degree they undertook and the explicit instruction they received on the teaching of their specific subject area. The qualified mathematics teachers are predominantly assigned the exam years (3rd and 6th year) and the Senior Cycle mathematics classes. Clearly this demonstrates that school principals are acutely aware that mathematical qualifications and experience are important in the teaching of mathematics but priority is given to exam years/Senior Cycle in their deployment of resources. This, unsurprisingly, is reflective of our exam orientated post-primary system and the norm of teaching towards the exam (NCCA, 2006). The irony is that specialist mathematics teachers should be employed at Junior Cycle and in resource teaching to ensure sufficient mathematical skills/concepts are developed at the early stages and to lay the foundation for further study in mathematics at second and third level education (Smith, 2004). It is important to establish effective mathematics teaching at all levels and year groups in port-primary education in Ireland as this is a significant contributory factor in student success in mathematical learning (Sanders & Rivers, 1996; Wenglinsky, 2000).

Another consideration is that the qualified mathematics teachers in this study are older and more experienced than the out-of-field teachers. This is perhaps a reflection of the fact that mathematics teaching was valued as a career option after undertaking a third level qualification in mathematics, up to the 1990s. Whereas now, students who pursue mathematics or courses with a significant mathematical content at third level have more 'appealing' career opportunities available to them e.g. finance, accounting, computing, engineering, etc. and many occupations are competing with each other for this limited number of mathematics graduates. Accordingly, the number of mathematics graduates opting for a career in mathematics teaching is dwindling. Likewise, the teaching problem is not alleviated by the fact that the number of students who undertake considerable study in the subject fields of mathematics and the physical sciences at second level is low and accordingly only small numbers pursue third level courses in these fields. Consequently, the challenge of recruiting teachers from this small group is a significant one. As a result a vicious cycle exists in that shortages of suitably qualified mathematics teachers results in poor teaching in post-primary education which contributes to low numbers undertaking mathematical study in third level education and entering the teaching profession (Darling-Hammond & Hudson, 1990). Therefore, concerns for the future of securing suitably qualified mathematics teachers for post-primary education is an issue that must be addressed in our education system to entice suitably qualified mathematics graduates into the field.

The principals who responded to the questionnaire place the strongest emphasis on teacher qualification affecting their assignment of teachers to teach mathematics in their schools, with availability of teachers, teacher experience and level of mathematics also having a significant influence on the assignment of teachers. Given that the qualified mathematics teachers were predominantly assigned Higher Level mathematics and examination years this reflects the principals' perception of the importance of post-primary students' performance in state examinations as reflecting achievement and success in mathematical learning. This point is further illustrated by the large number of out-of-field teachers assigned Ordinary/Foundation Level and resource teaching in non-exam years. Clearly, principals play a significant role in the assignment of teachers to teaching mathematics in post-primary education in Ireland.

SOME POSSIBLE SOLUTIONS TO THE PROBLEM OF OUT-OF-FIELD TEACHING IN IRELAND - RECOMMENDATIONS

Teaching is not perceived as a 'profession' by many and this is reflected in the fact that teachers not specifically qualified to teach mathematics are assigned mathematics classes in post-primary education in Ireland. This is in contrast to other professions such as medicine, law and engineering. For example, it would be unacceptable for neurologists to deliver babies, a malpractice lawyer to defend criminal cases, or biomedical engineers to design bridges (Ingersoll, 2001)! People perceive these careers as requiring special expertise but in contrast people are prepared to allow their children to be taught mathematics by out-of-field teachers which may have an impact on their future educational directions. This issue needs to be addressed in the Irish context.

The findings from this study support a "teacher deficit perspective" for the problem of out-of-field teaching as the main source of under qualification rests with the teachers themselves (Ingersoll, 2003, p.23). However, other factors are at work and these include availability of qualified mathematics teachers, lack of preparation/training, ability, knowledge, etc. Recommendations to improve this aspect of the problem include:

- Place greater emphasis on employing teachers specifically qualified to teach mathematics across all levels (Higher, Ordinary, and Foundation) and years (1st through 6th year) and enforce policy in this regard.
- Introduce postgraduate qualifications in mathematics and in mathematics education in order to provide opportunities for in- and out-of-field teachers to upgrade skills and achieve qualification to teach mathematics.
- Launch a recruitment drive in order to attract mathematics graduates into the mathematics teaching profession and accordingly improve the availability of suitably qualified mathematics teachers at post-primary education.
- Develop a coherent national policy for improving mathematics teacher quality and qualification.
- Encourage school principals/management to deploy teachers to subjects that they are specifically qualified to teach e.g. mathematics.
- Encourage school principals/management to work to redress the imbalance between the allocation of experienced mathematics teachers in exam and non-exam years, and between Junior and Senior Cycle.

- The phenomenon of out-of-field teachers of mathematics who are otherwise qualified post-primary teachers is a systemic problem that should be addressed by the Teaching Council in the context of its brief to regulate the teaching profession including mathematics teachers.

However, it is not enough just to identify that professional development is necessary, we need to identify what characteristics will achieve positive changes in teaching mathematics at post-primary education (Elmore, 2002; Garet, et al., 2001). Several essential features of effective professional development courses (and consequently improvements in teacher knowledge and mathematics instruction) have been identified in the literature. These include courses concerned with teacher subject knowledge and how students learn the subject content (Banilower et al., 2005); courses should be of long and sustained duration (Clewell et al., 2004); course content should be integrated into teachers' daily work rather than removed from the context of direct teaching (Cohen & Hill, 2000); and encourage collaboration and sharing of resources amongst teachers (Porter et al, 2000).

On the other hand, out-of-field teaching is not as such concerned with a lack of a teaching qualification, but rather with the mismatch of assigning teachers to teach the subjects they are not qualified to teach. Therefore, schools themselves and how they are managed also contribute to the existence of out-of-field teaching in mathematics. As Ingersoll (2003) highlights, recruiting new mathematics teachers and providing teachers with pre/in-service training will not eliminate the practice of out-of-field teaching if school principals continue to assign teachers to subject areas that they are not qualified to teach. This is largely at the discretion of the school principal but often occurs due to constraints such as teacher quota, subjects offered and contractual issues. However, in order to overcome this issue stricter regulation of how schools employ teachers needs to be introduced. Ingersoll (2003, p.23/24) provides a number of useful recommendations which include:

- Immediate support for out-of-field teachers should be provided in the in the form of, for example, resources, mathematics and teaching aids. These could be distributed to the schools and follow-up courses run for these teachers through a variety of delivery modes.

- In the case of rural or small schools meeting standards for qualified teachers will be more difficult, for example, they tend to have lower numbers of teachers and teachers in these schools are more often required to teach a variety of subjects regardless of background. In these settings, schools might consider sharing teachers, where schools could share the use of teachers with a qualification in mathematics.

- Schools could implement mechanisms of school-based management and distributed leadership where such decisions are shared with those who must live with, and may be held accountable for, the consequences – the teachers. Similarly, training and assistance could be provided to school principals in how to better balance tradeoffs between organizational *and* educational needs – the domain of instructional leadership.

As Jerald (2002) states we need to act immediately on the part of the problem that we can influence, set and enforce clear standards for teaching mathematics at post-primary level, maintain these standards, recruit new mathematics graduates to the teaching profession and provide incentives for schools/teachers demonstrating effective mathematics teaching. Clearly there is a need to develop a coherent national policy for improving mathematics teacher quality and qualification. This envisages the recruitment of high quality undergraduates/ graduates into mathematics teacher training; a need for post-primary schools to hire suitably qualified mathematics teachers and distribute them equally amongst the class groups/years; and a need to continuously support and sustain mathematics teachers once in the profession through improved working conditions and continuous professional development. Accordingly, improving teacher qualification and quality at post-primary level should improve students' mathematical learning and uptake of Higher Level mathematics, thus improving the uptake of science, engineering and technology subjects at third level in Ireland.

Figure 6: Towards a coherent national policy for improving mathematics teacher qualification and quality (adapted from Akiba & LeTrendre, 2009).

CONCLUSION

The study provides us with data that is often difficult to obtain. The authors demonstrate that one reason for the poor quality of mathematics teaching is the high proportion (48%) of out-of-field mathematics teachers employed in our post-primary schools. The negative impact of these teachers is accentuated by their concentrated deployment in the early years of Junior Cycle where students' attitudes and abilities need to be nurtured. The relevant literature strongly supports the link between teaching quality and performance in mathematics and the need for qualified mathematics teachers to teach mathematics to every year group (Darling-Hammond & Hudson, 1990; Sanders & Horn, 1994; Sanders & River 1996; Wright, Horn & Sanders, 1997). International comparative data discussed throughout this document demonstrates that Ireland is just one of many countries worldwide experiencing similar problems in mathematics teaching, and accordingly the situation in Ireland is not unique. The phenomenon of out-of-field teachers of mathematics who are otherwise qualified post-primary teachers is a systemic problem that is largely attributable to the operation of an 'open teachers' register' since before the foundation of the State. With the establishment of the Teaching Council since 2006 it is anticipated that tighter regulation of the teaching profession will transpire and lead to a reduction in the number of out-of-field teachers teaching mathematics.

Out-of-field teaching is an important concern as "highly qualified teachers may actually become highly *unqualified* when they teach subjects for which they have little background." (Ingersoll, 2001, p.21). To teach mathematics without a formal qualification is challenging and may have a negative effect on students' mathematical learning. A change in attitude towards the profession is required to effect change. In particular school principals need to understand the complexity and sophistication of the subject matter, and accordingly assign suitably qualified teachers to teach mathematics across all levels of post-primary education in Ireland.

This is the first time a study of this type into the nature of out-of-field teaching at post-primary education has been undertaken in the Irish context. This report presents the findings emerging from the data analysis in order to generate awareness amongst mathematics educators in the Irish context. This study was undertaken not to draw attention to the negatives but rather to assess what needs attention most urgently within the teaching of mathematics at post-primary level. Out-of-field teaching in mathematics is significant in proportion to the size of the mathematics teaching force and clearly needs to be dealt with in the Irish context. Many of these teachers enjoy teaching mathematics and this needs to be fostered. Also, school logistics relies on some of these teachers undertaking mathematics teaching in order to facilitate timetabling and staffing issues. Thus concern now lies with addressing the training needs of these out-of-field teachers (e.g. introducing training and qualification courses/ CPD). What these teachers lack is sufficient mathematical knowledge and pedagogical knowledge of how best to teach the subject. New directives and opportunities for improvement need to be targeted towards this cohort of mathematics teachers. In turn, improved student learning and achievement in mathematics may be achieved.

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