Please cite as: Delaney, S. (2005). Mathematics professional development for primary teachers: Looking back and looking forward. In S. Close, T. Dooley, D. Corcoran (Eds.) *Proceedings of First National Conference on Research in Mathematics Education* (pp. 235-249). Dublin, Ireland: St. Patrick's College.

MATHEMATICS PROFESSIONAL DEVELOPMENT FOR PRIMARY TEACHERS: LOOKING BACK AND LOOKING FORWARD

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[This paper differs in minor ways from the version published in the conference proceedings]

Whether one calls it in-service education, in-career training, lifelong learning, professional learning or professional development, it is now widely acknowledged that teacher education continues beyond the initial pre-service degree or diploma programme. Consequently, professional development is becoming a more significant part of the field of mathematics education in Ireland. The present capacity for professional development in mathematics is a product of decisions that were taken and opportunities that were seized by individuals and by the system in the past. This paper considers the current state of mathematics professional development in Ireland. Journal articles and books on mathematics education in Ireland are used as data. International comparisons are used to highlight aspects of Irish professional development provision in mathematics. It also proposes, for discussion, four aims for the future of mathematics professional development which are achievable within the current infrastructure.

Introduction

Honora Rice has been teaching for ten years. She teaches thirty-one third class pupils in a twelve-teacher school in a large town outside Dublin. Five pupils in the class speak English as a second language and Honora believes that two pupils, who need a lot of individual attention, should be in a special needs class. She works hard and loves her job. Colleagues and parents regard her as a very good teacher.

She particularly enjoys teaching maths and believes that she is good at it. In her opinion, the secret of success, is to "overlearn." Every pupil completes every problem in the textbook and if they get a problem wrong, they must re-write it correctly. Pupils learn tables by rote. Honora has observed some of her colleagues moving away from asking pupils to learn things by rote but she believes that those teachers will eventually revert to the memorizing approach. That method worked for Honora in primary school. Doing every sum in a 'drill and practice' textbook prepared her for secondary school entrance exams. Even if pupils don't understand everything at the time, understanding will follow.

Not seeing the need for it, Honora is unlikely to voluntarily embark on professional development in maths. But she willingly attends mandatory professional development days and is happy to share her beliefs about teaching maths with other teachers. For

teachers like Honora, most recent professional development has come in the form of curriculum seminars and school planning days.

Formal professional development begins when a prospective teacher enrolls on a pre-service programme. Some researchers (e.g. Feiman Nemser, 1983, ; Richardson, 1996, , 2003) claim that informal learning to teach begins much earlier and Lortie (1975/2002) describes as a powerful "apprenticeship of observation" the years that a teacher spends as a pupil in school. For the purposes of this paper, professional development refers to how teachers learn once they complete their pre-service teacher education course and they begin to teach. Various terms are used to describe the learning in which teachers engage during their careers. Hyland and Hanafin (1997) refer to incareer development. Sugrue (2002) identifies four widely-used terms: in-service, lifelong learning, professional development and professional learning. Sugrue favours the latter two terms for their precision and their connotations of development. When the term professional development is used in this paper, it incorporates the idea of professional learning.

Honora represents both a hope and a challenge for professional developers in mathematics. She is hardworking, energetic and interested in her work and wants what is best for her pupils. She also has deeply-held convictions about good mathematics teaching that are at variance with aspects of the 1999 curriculum which emphasises understanding, higher-order thinking skills and discussion (Government of Ireland, 1999). In a case like this a professional developer and a teacher may have different ideas about what constitutes good mathematics teaching. This can create tension for the teacher who aspires to teach well but whose approach to instruction differs from the professional developer's. It can create tension for the professional developer who may have only a day or two to work with the teacher and who is consequently reluctant to undermine the teacher's confidence in an approach that works. These tensions prompt some questions relating to teachers' professional development in mathematics.

What would it take for a teacher like Honora to contemplate the benefits of teaching mathematics differently? Given the infrastructure that exists in Ireland for teachers' mathematics professional development, what are reasonable outcomes for teacher professional learning? How might professional development in mathematics be envisaged for an individual teacher over the course of that teacher's career?

In order to address these questions, this paper proposes four aims for mathematics professional development of Irish teachers. The aims relate to professional discourse, teachers' mathematical knowledge, supporting disadvantaged pupils and assessment of pupils' progress. These aims emerge from analysing data on mathematics teaching and on mathematics professional development in Ireland over the past fifteen years. The data consist mainly of articles and books on the topic, published since 1990 and they are supplemented by primary source data and unpublished research. These data are considered in the light of professional development research in the United States.

The paper begins by describing four aspects of mathematics education in Ireland: professional discourse, assessment of mathematics performance, disadvantage and

mathematics and teachers' mathematical knowledge. The first three aspects are highlighted in two recently-published reports by the Department of Education and Science (DES) (Department of Education and Science, 2005a, , 2005b) and the fourth is attracting much attention from international mathematics education scholars (e.g. Ball, Lubienski, & Mewborn, 2001) and has recently been studied in this country (e.g. Delaney, Zopf, Ball, & Hill, 2005, ; Wall, 2001). Next, aspects of the professional development infrastructure for mathematics are outlined. These are teachers' professional networks, summer courses and courses for credit, the Primary Curriculum Support Programme and professional reading. In the discussion section, the four aims for future professional development in mathematics are outlined and the paper concludes with a single aim for mathematics education researchers. Beliefs of Honora Rice, a composite portrait of several Irish teachers, are used throughout the paper to illustrate or to counter some of the points that are made.

THEMES OF MATHEMATICS EDUCATION IN IRELAND

Professional Discourse

In a review of research on contemporary professional development, Wilson and Berne (1999) categorized the research they reviewed under three headings: opportunities to talk about subject matter, opportunities to talk about students and learning and opportunities to talk about teaching. Common to the three categories is the idea of talk. In her book *California Dreaming: Reforming Mathematics Education*, Wilson (2003) contrasts how the disciplines of mathematics and of teaching are practised. Mathematicians present their thinking for public review in articles and at conferences and in seminars and they "engage in sometimes sharp discussions about the validity and quality of one another's work" (p. 198). In contrast, teachers rarely talk to peers about their work or document it. Consequently their ideas about teaching are rarely challenged, or disseminated following peer review.

In Honora's school, one colleague drafted the school plan for mathematics. Although it was presented to a staff meeting, Honora remembers that the brief discussion centred exclusively on how subtraction should be taught. Irish teachers rarely discuss their teaching with colleagues. According to the 1995 TIMSS report, only seven per cent of Irish fourth grade students sampled, were taught by teachers who reported meeting with colleagues at least once a week to discuss teaching (Mullis et al., 1997, p. 158). This was the lowest meeting rate of the twenty-six participating countries, with only Hong Kong (9%) teachers reporting a similarly low number of meetings.

With designated curriculum planning days, the level of professional discourse and collaborative planning might have been expected to rise. But an evaluation of curriculum implementation conducted this year by the DES found that "whole school planning for mathematics was weak or had scope for development in more than half the schools inspected" (Department of Education and Science, 2005a, p. 26). This study was based on observation, examination of school documents and semi-structured interviews with principals and teachers from 61 classes in 28 schools. The study further claimed that the lack of whole school planning in many schools "impacts negatively on classroom

practice" (p. 32). Further research is needed to investigate why professional discourse among primary teachers remains low.

A study of Irish post-primary mathematics teaching, involving video data and interviews with pupils, teachers, principals and parents, identified barriers to professional discourse in Irish post-primary schools. Teachers work in "autonomous units" and this combined with the "speed and intensity" of teaching militates against reflecting on practice. Indeed, of ten teachers interviewed, nine "had not experienced an alternative approach [to teaching mathematics] throughout their teacher training or their teaching career." (Lyons, Lynch, Close, Sheerin, & Boland, 2003, p. 276 and p. 263). Not being accustomed to discussing the teaching of mathematics Honora is not sure how it might change her teaching and she does not know where she and her colleagues would find the time to engage in this kind of professional discourse.

Disadvantage and Mathematics

Professional development could also play an important part in raising mathematics achievement among disadvantaged pupils. The DES regards a child as disadvantaged if "because of economic, cultural or social factors, the competencies that he or she brings to school differ from those valued in schools" (Department of Education and Science, 2005b, p. 14). In a recent study of 1,080 pupils in nine schools designated as serving areas of disadvantage, almost two-thirds of pupils' mathematics scores fell on or below the twentieth percentile and less than 3% scored above the eightieth percentile. The problems were even more pronounced in fifth and sixth classes. The researchers note limitations in generalising these findings: the sample of schools is small and the test scores data had been collected by individual schools prior to the study.

In another part of the study of disadvantaged schools, inspectors interviewed teachers and found that less than 15% of them had attended specific courses on the teaching of numeracy. Many teachers were unaware of courses that they could attend to develop their skills in teaching numeracy and the inspectors conclude that significant improvement is needed in the professional development of teachers to equip them to work with disadvantaged pupils. Honora teaches in a school in a relatively affluent area and it is not designated disadvantaged. Five children in her class, however, are non-native speakers of English and she struggles to support their mathematics learning.

Mathematics and Assessment

Honora administers a mathematics test and a tables test to her students on alternate weeks. In addition, she and her colleagues administer a standardised test annually to all pupils in June. A DES study of literacy and numeracy in disadvantaged schools found evidence of poor practice in relation to the analysis and use of assessment in mathematics in well over half the schools studied (Department of Education and Science, 2005b). Another study by the DES found that this problem is not restricted to schools that serve students who are designated as disadvantaged (Department of Education and Science, 2005a). In this study more than half the 28 schools surveyed had unsatisfactory approaches to assessment in mathematics. One third of the sixty-one teachers assessed

pupils using only standardised tests and almost half of the teachers did not use the results of standardised tests appropriately.

The predominance of standardised tests in the DES study seems to contradict a finding of a National Council for Curriculum and Assessment (NCCA) study which found that almost all teachers surveyed reported using teacher observation as a form of assessment at least a few times a week and three-quarters reported using teacher-designed tasks and tests at least a few times a week (National Council for Curriculum and Assessment, 2005). The difference can be explained by the different data that were collected. The NCCA study administered questionnaires to teachers in 170 schools and they interviewed children, parents, principals and teachers in six case-study schools. In contrast, observing practice and studying school documents enabled the DES to identify shortcomings in teachers' recording of pupils' achievement and discrepancies between documented and actual assessment policies. Ten percent of teachers in the NCCA study expressed the wish to use more assessment in implementing the mathematics curriculum. The DES study specifically identifies support services (including the School Development Planning Support initiative and the Primary Curriculum Support Programme) which can assist teachers in using formative assessment effectively. Most of Honora's assessment is summative rather than formative. Although she believes her weekly tests motivate the pupils, she realises that the results do not inform her teaching. She uses observation as a form of assessment also but finds it somewhat haphazard in nature and is interested in learning how it might become more systematic.

Teachers' Mathematical Knowledge

Growing recognition of the mathematical complexity of teaching mathematics, even to young children, has lead to several researchers studying teachers' mathematical knowledge (Ball et al., 2001). Honora remembers a colleague, who teaches senior infants, enquiring in the staff room one day whether she should tell her pupils that a circle has one side, no sides or infinitely many sides. Similarly, analysing how a pupil got a particular wrong answer or deciding if a pupil's alternative problem solving approach is generalisable requires good knowledge of mathematics. In one study of Irish student teachers, Wall (2001) found that a small number of prospective teachers struggled with the kind of mathematics that sixth class pupils are expected to know. Ball (Ball, Thames, Phelps, & Hill, 2005) and others argue that knowing sixth class mathematics is far from sufficient mathematical knowledge for engaging in the work of teaching mathematics. Honora remains to be convinced that teaching primary school mathematics is mathematically demanding. Having studied honours maths in her leaving certificate examination, she is more confident mathematically than several of her colleagues, one of whom refuses to teach senior classes because she knows she would find teaching mathematics challenging.

PROFESSIONAL DEVELOPMENT INFRASTRUCTURE

In the previous section I have explained some of what we know about mathematics education in Irish schools in relation to practising professional discourse, teaching students who are disadvantaged in some way, assessing pupils' mathematical achievement and studying teachers' mathematical knowledge. Using the persona of

Honora Rice, I have hinted at the role professional development may play in improving practice in these areas. Professional development is no silver bullet. It cannot be delivered on demand, in a guaranteed timeframe or in equal measures to all teachers. Professional development is an ongoing process which must be credible to teachers and must be seen to enhance teaching and learning. It requires good professional developers and a strong infrastructure that supports and in turn develops the developers. The paper now looks at some components of the infrastructure for professional development in Ireland: professional networks, summer courses and courses for credit, the Primary Curriculum Support Programme (PCSP) and professional reading and writing.

Professional Networks

Between 1979 and 1988 teachers who were interested in sharing ideas and talking about mathematics teaching could join the Primary Teachers Mathematics Group. Dr. Seán Close, a lecturer in mathematics education in St. Patrick's College of Education, established this group in October 1979. Its aims were to (i) provide a forum for primary teachers to exchange ideas and methods about mathematics instruction and to discuss important issues in mathematics in primary schools and (ii) to promote co-operation between teachers both within schools and between primary and post-primary schools. An initial group of twenty members grew to over one hundred and in 1982 the Primary Teachers' Mathematics Group became the primary branch of the Irish Mathematics Teachers' Association (Primary Teachers' Mathematics Group, 1982 est.). For several years the Group organised workshops, talks and seminars and it produced a newsletter *Pegboard*. It also engaged in research activities, and one study resulted in a number of conference and journal papers (e.g. Mulryan & Close, 1982). Eventually, however, the group's membership declined to around 30 members. Funds, which came from membership fees, were low, attendance at the workshops dwindled and the group disbanded in 1988. Seán Close commented that at this time "all the focus [of teachers' professional development interest] was on computers"[1].

In California, Wilson found that participating in mathematics networks offered teachers the experience and the confidence to become teacher leaders and to offer professional development to other teachers (Wilson, 2003). I do not claim that the Irish primary teachers' network made a similar contribution to developing teacher leaders. Nevertheless, three former members of the Irish Mathematics Teachers' Association subsequently became members of the National Council for Curriculum and Assessment's primary mathematics curriculum sub-committee that designed the 1999 mathematics curriculum (Government of Ireland, 1999). Further, in 2001 two former members of the group became members of the PCSP professional development team in mathematics.

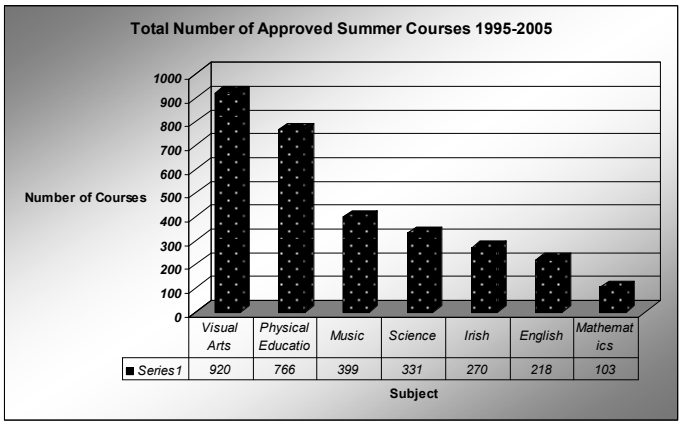
More recently, attempts have been made to re-establish a network for teachers interested in the teaching of mathematics, the Primary Teachers' Mathematics Association. This Association was established in 2000 and it organises an annual conference and occasional workshops, delivered by teachers and teacher educators, and it produces two newsletters per year. The Association has a membership of around 100 teachers – less than 0.5% of Irish primary teachers.

Summer Courses

Many primary teachers attend week-long summer courses on curriculum and general education topics and in 2005 teachers could also choose an online course. Little published data exist regarding the quality or impact of these courses on teaching and learning. Figure 1 shows how many courses were approved by the Department of Education and Science (DES) in several curriculum areas between 1995 and 2005. In contrast to other curricular areas, especially visual arts, physical education and music, few mathematics courses were approved. Limited opportunities, therefore, have existed on DES-approved courses for Irish teachers to develop their mathematical knowledge or their pedagogical knowledge in mathematics. This has made it more difficult for teachers to develop the skills and the confidence necessary to become teacher leaders in mathematics.

Figure 1

Summer courses for teachers in curriculum subject areas that were approved by the Irish Department of Education and Science between 1995 and 2005[2]



Courses for Credit

Another route to becoming a teacher-leader is to take a course for certification. Few institutions offered certified postgraduate programs in primary mathematics education prior to 2000. In that year at least one college introduced a part-taught Masters Degree programme in primary mathematics education and at least two institutions are offering Masters Degree programmes in mathematics education beginning in autumn 2005[3].

The Primary Curriculum Support Programme

The Primary Curriculum Support Programme (PCSP) was established to support the implementation of the primary curriculum that was revised in 1999. In-service seminars, school-based planning days, a website and newsletters were the principal professional development instruments used by the PCSP which worked closely with the network of education centres that had been expanded during the 1990s.

Twenty-one mathematics trainers,[4] all primary school teachers, were appointed in 2001 to deliver two one-day seminars to every primary school teacher in the country. One of the criteria for selection was "experience in both attending and delivering courses in primary mathematics."[5] Trainers began their own professional development in June 2001 and this continued in September and throughout the 2001-2002 school year. Specialist input was

provided for the newly-appointed trainers by mathematics education lecturers, a teacher, a researcher and representatives of the Department of Education and Science.[6]

A PCSP design team decided that seminars for teachers should emphasise changes in mathematics teaching methodologies. These included more talk and discussion, active learning/guided discovery, problem solving, teaching skills through content, using the environment and collaborative/cooperative learning. Decisions about emphases were made partly on the basis "that the main changes to the maths curriculum were methodological rather than content-based." [7]

In the DES implementation study, teachers attributed their general "good understanding of the structure of the curriculum" to the work of the PCSP (Department of Education and Science, 2005a, p. 31). A full review of the PCSP, commissioned by the DES and the NCCA, has been completed by researchers from Trinity College, Dublin but it is not available for study until it has been considered by the NCCA council on September 22nd 2005.

Although teachers bring credibility to the role of delivering professional development, the California experience prompted Wilson to caution that teachers teaching teachers is not problem-free. She believes that professional development in mathematics should provide participating teachers with deep mathematical knowledge as well as deep pedagogical knowledge. Therefore a teacher leader offering professional development in mathematics needs to have "sound mathematical knowledge" (Wilson, 2003, p. 93). But in her research Wilson observed frequent workshop sessions that were "chock-full of important information about instruction, reform and assessment, and weak on mathematics" (Wilson, 2003, p. 94). Wilson's role as an evaluator of professional development is significant here because without a good understanding of mathematics, she may not have noticed the mathematical shortcomings of the workshops.

Professional Reading

Even if teachers are not participating in professional networks or attending courses, they may be encountering new ideas about teaching and learning through professional reading. Irish teachers, however, have a low level of professional reading. The 1995 TIMSS results showed that pupils at fourth grade level[8] were taught by teachers who reported spending an average of 0.6 hours per week on professional reading and development, the lowest time of any participating country (Mullis et al., 1997, p. 157). This situation may be due to limited access to relevant journals and books rather than a criticism of individual teachers (Martin & Morgan, 1994). The intervening years have seen the publication of an education act, a new curriculum and almost a tripling of expenditure on professional development in the years from 1996 to 2000 alone (Drudy & Coolahan, 2002) and the level of professional reading may have changed.

InTouch, the monthly magazine of the Irish National Teachers' Organisation (INTO), is circulated to almost every primary teacher. A survey of the teacher tips section and the 'Teacher to Teacher' section for 2004 shows that the journal contained no articles on mathematics in that year (See Table 1).

Visual Arts	Social Environmental and Scientific Education	Music	2 or more subjects integrated.	English	P.E.	Drama	Irish	Maths
13	11	2	2	1	1	1	0	0

Table 1
Number of articles related to specific curriculum areas in the "Teacher to Teacher" and "Tips" section of the Irish National Teachers' Organisation's journal InTouch *in 2004.*

The absence of articles in mathematics is significant because *InTouch* is the most widely circulated education magazine in Ireland[9] and the one that primary teachers are most likely to read. On the positive side for mathematics, the first two editions of the magazine in 2005 contained mathematics articles written by members of the PCSP. The topics, mathematics trails and the one-hundredth day of school, were topics that had previously been the subject of workshops organised by the Primary Teachers' Mathematics Association. This is an example of how a network of teachers can potentially disseminate ideas about mathematics teaching to a much wider audience.

DISCUSSION

Practising teachers may engage in professional development that is mandatory, voluntary or incidental (Wilson & Berne, 1999). In the United States the various activities combine to form what Wilson and Berne (1999) describe as a "patchwork of opportunities" for teacher learning which are irregular and disconnected. Ball and Cohen (1999) share similar concerns when they bemoan the absence of "anything remotely resembling a comprehensive perspective on professional learning" (p. 4).

In Ireland, with the exception of the PCSP activities, teachers participate in the professional development opportunities described above on a voluntary basis. Many teachers, like Honora, will not become involved in these activities because they have limited time to dedicate to professional development, because they do not perceive the need for professional development in mathematics or because they have experienced unsatisfactory professional development in the past. In the 1999 National Assessment of Mathematics Achievement, only 29% of pupils were taught by a teacher who had attended some mathematics incareer training. The average number of training hours attended by teachers was 9 hours. Of the teachers who attended incareer development 47% of them were either dissatisfied or very dissatisfied with the courses.

Thanks to the PCSP and institutions offering masters degrees in mathematics education, the infrastructure for professional development in mathematics is becoming stronger, but more remains to be done. Greater coordination between the different components of professional development is also needed. It is envisaged that the Teaching Council will adopt such a coordinating role ("Teaching Council Act, 2001," 2001) although it will face several challenges around quality, usefulness, opportunities and incentives, balance between mathematics professional development and other subjects, meeting the needs of diverse teachers and evidence of effectiveness.

Despite the challenges, the complexity of teaching mathematics makes professional development highly desirable. Four aims for professional development in mathematics are presented here. Each element of the professional development infrastructure, working in a coordinated way, can play its part in achieving these aims.

1. To promote professional discourse among teachers

If teachers at school level engage in sustained and honest professional discourse, ideas about teaching mathematics can be shared and challenged. Discussing mathematics teaching requires language that teachers do not frequently use and this is not something that can be learned in a one-day seminar or even during one week. Professional discourse is a process to be learned and practised throughout the teacher education process. Teacher educators and professional developers can practise it and model it for pre-service and practising teachers who can in turn practise it themselves. As professional developers and teachers practise professional discourse, other barriers to such discourse in schools need to be identified and addressed. Over time, mathematicians and other education partners may join the discourse. Indeed this research conference is an example of such discourse.

Mathematical topics like estimation and data that have been prioritised by the DES could be used to stimulate discussion. Similarly, Japanese lesson study (e.g. Stigler & Hiebert, 1999), where teachers collaboratively plan, observe and discuss a lesson, or video records of teaching practice (Ball & Cohen, 1999) might be used as discourse stimuli.

2. To develop teachers' mathematical knowledge

Since Shulman emphasised the importance of subject matter knowledge for teachers (Shulman, 1986), researchers have tried to describe the mathematical knowledge needed to do the work of teaching. Researchers at the University of Michigan (Hill, Rowan, & Ball, in press) have done substantial work in describing the mathematical knowledge that teachers need to teach mathematics and correlating it with student achievement. Developing teachers' mathematical knowledge should be a cornerstone of future professional development.

3. To raise the mathematical achievement of children who are disadvantaged

Disadvantaged children are not achieving well in Irish mathematics classes. Teachers feel unprepared to teach these children and they are unaware of relevant and available professional development options. Raising the mathematical achievement level of all children is another priority for future professional development.

4. To improve the assessment of pupils

If teachers are to build on pupils' existing mathematical knowledge they need to become skillful in assessing that knowledge and in using the assessment findings to inform their subsequent teaching. Skillful assessment is difficult and many teachers need additional support to assess pupils effectively.

These aims are not exhaustive and do not include professional development in areas such as integration with other subjects, problem solving or technology and mathematics. The aims are not specific to a particular curriculum but rather address the ongoing

development of the professional over the course of a teaching career. Although they will not be easy to achieve, given time and determination they are possible within the existing infrastructure and they can contribute to strengthening and developing that infrastructure.

Finally, having outlined four aims for professional development of Irish teachers the paper concludes with an aim for mathematics education researchers. It is that researchers study the capacity and the achievements of Ireland's professional development infrastructure in mathematics. Internationally, the "pedagogy of professional development" (Ball & Cohen, 1999) is in its infancy. By studying professional development we can come to understand how professional development impacts on the practice of teachers like Honora and others and on pupil achievement. Through such research we can learn the extent to which the aims above have been achieved, which additional ones are desirable and what a continuum of mathematics professional development for a primary teacher's career might look like.

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[1] Dr. Seán Close, personal communication, March 4th 2005.

[2] Numbers exclude courses on generic topics such as educational disadvantage, learning difficulties, early childhood education, pupil assessment or technology which may or may not have a mathematics component. The numbers relate to courses advertised in the official list of courses and the numbers include some courses which were subsequently cancelled.

[3] The institutions referred to are St. Patrick's College Drumcondra and Trinity College Dublin. Source: *InTouch*, journal of the Irish National Teachers' Organisation, January/February and March 2005.

[4] Despite its connotations of instruction and drill and practice this term is widely used in relation to members of the PCSP who work directly with teachers.

[5] Valerie O'Dowd, Assistant National Coordinator, PCSP, personal communication, April 10th 2005.

[6] Valerie O'Dowd, personal communication, April 12th 2005.

[7] Valerie O'Dowd, personal communication, April 10th 2005.

[8] Participating children had an average age of 10.3 years but were not necessarily in fourth class in Ireland (Mullis et al., 1997, p. 24).

[9] It is distributed to its 24,977 members in the Republic of Ireland and to educational institutions.