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Demographic profile and perceived INSET needs of secondary Mathematics teachers in Limpopo province

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The findings of a study on the demographic profile and perceived INSET needs of secondary Mathematics teachers in Limpopo province are described. The survey instrument employed was the Science Teacher Inventory of Needs for Limpopo province (STIN-LP). *Most teachers who responded to this survey teach at a rural or township school, are between 20 and 40 years old, and have between four and ten years experience in teaching Mathematics. Standard 10 is the highest academic qualification of half of the teachers, with 67% of teachers having an M+3 as their highest professional qualification. Teachers indicated interest in all the 38 INSET need items included in the STIN-LP with motivating learners to learn Mathematics, using audio-visual equipment and applying mathematics to daily life of learners among the most important need. The least support was indicated, among others, for needs related to the history of mathematics, improving content knowledge, how mathematics is used in society, and teaching large classes. Poor communication of INSET activities was reported to be the greatest barrier to INSET participation. Implications of the findings are discussed.*

Keywords: in-service education and training (INSET); mathematics teachers; needs assessment; Limpopo (Northern Province); surveys; teacher characteristics

Introduction

The South African government's new National Curriculum Statement for Grades 10 to 12 (Department of Education, 2003a) — in line with its earlier White Paper on Science and Technology (Department of Arts, Culture, Science and Technology, 1996) — makes it clear that adequate skills and knowledge of mathematics and the physical/life sciences are believed to be a vital component of successful contemporary life and socio-economic development. Yet, if the number of candidates who write the Senior Certificate examination is taken as an indication of the number of Grade 12 learners who take Mathematics in school (as opposed to merely [re]writing the examination), enrolments in this subject decreased by 29% between 1999 and 2003 in Limpopo province (Department of Education, 2000; 2001; 2003b). Moreover, although pass rates in the Senior Certificate examinations for this subject have increased over the same period, the pass rates for learners from Limpopo province are consistently the lowest provincial results in the country (Department of Education, 2000; 2001; 2003b). It is therefore apparent that this inadequate state of mathematics education in Limpopo province demands a meaningful response.

Among the many factors that influence achievement in Mathematics, the

role of teachers' pedagogical knowledge and skills in their subject area is acknowledged to be key. Teachers' craft knowledge — that is, knowledge and beliefs regarding pedagogy, students, subject matter and curriculum (Van Driel, Verloop & De Vos, 1998) — is related to teacher effectiveness (Darling-Hammond, 2000; Hill, Rowan & Ball, 2005). Moreover, there is overriding evidence that teacher quality in terms of teacher preparation and qualification strongly influence students' level of achievement (Darling-Hammond, 2000; Darling-Hammond, Berry & Thoreson, 2001; Goldhaber & Brewer, 2000). However, it is widely recognised that, for historical reasons, the training of Mathematics teachers in rural areas such as Limpopo province is of variable, but largely inadequate, quality (Arnott, Kubeka, Rice & Hall, 1997; Mailula, 1995; Ngoepe, 1995). An important initial response to the inadequate state of mathematics education in Limpopo must therefore include the establishment of effective, widely available in-service teacher education and training programmes (INSET).

The effectiveness and the success of INSET programmes in general depend on at least two factors. First, efficient and effective planning of INSET activities on a provincial level requires that planners have at their disposal accurate demographic information, as well as information on academic and professional qualifications, of relevant subject teachers in the Province. The current Limpopo Department of Education was established in 1996 through the merging of seven different departments of the apartheid era (*viz.* educational departments from the former Venda, Lebowa and Gazankulu, the former Department of Education and Training, the Department of Education and Culture, the House of Representatives, the Department of Education and Culture, the House of Delegates and the former Transvaal Education Department) (Lee & Glover, 1995 [Addendum F]). The teacher database in these departments was of varying quality and reliability, and these databases are therefore not useful in providing information applicable to the entire Limpopo province. Although so-called 'snap surveys' are now conducted annually by the Limpopo Department of Education, these surveys do not ask for comprehensive information on teachers' demographic and professional details (MA Seopa, pers. comm.). Therefore, accurate and reliable detailed demographic information on mathematics teachers for the whole province is, for all intents and purposes, not widely available. In fact, with reference to the South African education system as a whole, a recent Annual Report of the Department of Education (DoE, 2007:71) states that "… the uncertainty with regard to the number of under-qualified and unqualified teachers in the system is a challenge to the system".

The second factor influencing the effectiveness and success of INSET programmes is the need for such activities to address expressly the perceived INSET needs of teachers (Zurub & Rubba, 1983). Lubben (1994) argues that INSET activities are usually structured on the basis of the observations of INSET providers and the requests of educational administrators, without consulting teachers to identify their priority INSET needs. When teachers are

not consulted about their work environments, and planners assume that they know what is best for teachers, teacher morale suffers, INSET programmes are poorly attended, and achievement is scarcely influenced (Mecca & Klindienst, cited by Baird & Rowsey, 1989). However, Baird, Easterday, Rowsey and Smith (1993) maintain that INSET programmes based on the expressed needs of teachers yield more positive responses from teachers. Smith and Haley (cited by Easterday & Smith, 1992) add that needs-based programmes can also boost programme attendance in contrast to those that are not applicable to teachers' classroom needs. Indeed, the above sentiments were also echoed by teachers, INSET providers, department of education officials, and academics attending the 1995 Conference on Science, Mathematics and Technology Education Policy in Limpopo (Lee & Glover, 1995).

In this study we sought to (a) determine reliable demographic information of Mathematics teachers; (b) determine the perceived INSET needs of these teachers; and (c) investigate possible associations between INSET needs and demographic variables.

Method

The study was designed as a snap survey of demographic profiles and perceived INSET needs of secondary Mathematics teachers in Limpopo province. The survey of Mathematics teachers was part of a larger study that also included Physical Science and Biology teachers, for whom findings are reported elsewhere (Mabye, 2004; Manyelo, 2004). Firstly, a survey methodology using a paper-and-pencil instrument was used. Secondly, focus group interviews with 34 secondary Mathematics teachers were conducted in order to increase the trustworthiness of the survey results.

Questionnaire used

The survey instrument used in this study was developed from the *Science Teacher Inventory of Needs* (STIN-3) of Baird *et al.* (1994). Although the original STIN was found to be reliable and valid in other countries, its use in a different educational context demanded that its validity be determined with respect to perceived INSET needs of Mathematics teachers in Limpopo province. The STIN-3 instrument was thus adapted, modified and validated for use in the South African and the Limpopo context in particular, and was called the *Science Teacher Inventory of Needs for the Limpopo Province* (STIN-LP) containing 98 items (Laugksch, Rakumako, Manyelo & Mabye, 2003). Information on the reliability of STIN- LP was obtained by determining the items' alpha coefficient and the instrument's Guttman split-half reliability coefficient after the instrument had been administered. The alpha coefficient reliability for this instrument was 0.97 and the adjusted Guttman split-half reliability was 0.83.

The STIN-LP is arranged into six sections. Section A contains two items that identify teachers in terms of the subject they teach (i.e. Mathematics, Physical Science or Biology) and the subject in which they teach the most lessons per week. Section B consists of 47 items that assess teachers' INSET

needs in the seven original categories of STIN, that is, (a) improving personal competence (6 items), (b) specifying objectives for instruction (2 items), (c) diagnosing and evaluating learning (3 items), (d) planning instruction (14 items), (e) delivering instruction (5 items), (f) managing instruction (7 items), and (g) administering instructional facilities and equipment (10 items). In these 47 items, response options range from "not familiar" to "great need", as in the original STIN. Examples of needs items from the seven categories are included in Author (date). Section C contains 26 items that use forced-choice options to determine demographic information about teachers and their schools (e.g. type of school, highest professional and academic qualification, age, teaching experience, greatest professional need, etc.). Sections D and E are not pertinent here and are thus not described. The last item in STIN-LP, and the only item in section F, asks for the EMIS number of the teacher's school (a unique reference number). In STIN-LP, teachers were also given the opportunity to list needs not covered in the instrument on a blank page of the questionnaire.

Administration of questionnaire

STIN-LP was administered with the help of the Limpopo Province Department of Education, following approval of the study from the Superintendent-General of the Department. The questionnaires were distributed to, and collected from, principals of all secondary schools in Limpopo offering Mathematics, via the District Offices of the Department. Questionnaires were accompanied by letters to District Managers and Curriculum Advisors, as well as the approval letter from the Superintendent-General requesting cooperation and assistance from all individuals involved in the study. Principals then were responsible for ensuring the mathematics teachers in their school completed the STIN-LP questionnaire. It was assumed that each school had an average of two Mathematics teachers, as Mathematics is compulsory from Grades 8 to 10. The reasonableness of this assumption was confirmed by two senior Limpopo Province Department of Education officials. The total number of secondary schools in the Limpopo Province was established with the assistance of the provincial Department of Education. A total of 3,258 questionnaires were thus distributed to 1,629 secondary schools in Limpopo province.

Focus group interviews

Teachers were purposefully selected for focus group interviews from six districts in four of the seven regions in Limpopo province. The selection of the districts was based on the type of schools teachers taught at (i.e. rural, township, urban), as it was assumed that the school type might have a major impact on INSET needs of teachers. A total of 51 teachers in groups of three to ten were interviewed. These groups were organised with the help of principals, Curriculum Advisors and District Managers. Seven interview sessions were held with four groups of only Mathematics teachers (27), and three groups of mixed teachers (24), that is, Mathematics, Physical Science and

Biology teachers in one group. The mixed focus group interviews were conducted jointly in order to maximise logistical efficiency at district level. Out of a total of 51 teachers who were interviewed, 34 were Mathematics teachers. Of these, 23 teachers were male.

Semi-structured interviews were used, as key questions relating to the research objectives were prepared prior to the interview. The interview questions were designed to elicit perceived INSET needs of Mathematics teachers and included questions such as, for example, "What are your greatest professional needs as a Mathematics teacher?", "Which further skills would you like to acquire in order to be an effective Mathematics teacher?", and "What topics /themes would you like to see included in INSET workshops?".

Results

Five hundred and fifty-two[1] Mathematics teachers (Grades 8–12) in the seven administrative regions of Limpopo responded to the STIN-LP questionnaire, yielding a teacher response rate of 17%. Respondents were from at least 324 schools,[2] indicating that Mathematics teachers in at least 20% of all secondary schools in Limpopo were surveyed. Nine out of ten teachers who responded had as their highest professional qualification a matric plus either three or four years further education, and were thus qualified to teach Mathematics (Table 1) at the time of the survey. Given our knowledge and experience of the educational context of Limpopo province, such a high proportion of qualified teachers in the secondary Mathematics teaching corps is extremely unlikely. It is therefore concluded that it would appear as if all teachers did not feel free to complete the questionnaire, even though teachers were requested to complete the questionnaire anonymously. The reluctance to respond may have been due to fear of being disadvantaged if it was found that their qualifications were not relevant to the subjects they taught (personal communications from some principals and Curriculum Advisors). The findings presented here are thus not representative of all Mathematics teachers in the province but largely of those who are qualified to teach Mathematics.

Fifty-two percent of the teachers taught mixed secondary grades (i.e. a combination of Grades 8–12), 14% of them taught junior grades (Grades 8 and 9), and 34% taught senior grades (Grades 10–12).

Demographic profile

An overwhelming majority of Mathematics teachers who responded came from rural schools (85%), a few from township schools (10%), and very few from urban schools (5%). Trends identified with respect to this latter group need to be treated with caution due to their small sample size. The vast majority of responding Mathematics teachers was male, but this was not so in urban schools (Table 1). Seventy-eight percent of Mathematics teachers were between 25 and 40 years old. Most teachers were 31 to 40 years old, and older teachers only made up one-fifth of teachers who responded. A larger proportion of urban than non-urban teachers were older than 40 years (Table 1).

Table 1 Teachers' sex, age, qualifications and years of experience in teaching Mathematics by type of school

Variable	Category	% of rural (n = 456)	% of township (n = 52)	% of urban (n = 25)	% of total (n = 541)
Sex	Male	72	71	48	70
	Female	28	29	52	30
Age	24 and younger	2	2	0	2
	25–30	23	25	8	22
	31–40	59	38	28	56
	41–50	14	29	32	16
	Over 50	2	6	32	4
Highest	< Std 10	5	4	0	5
academic	Std 10	59	36	8	54
level in	1st year univ.	16	16	24	17
Mathematics	2nd year univ.	8	6	48	9
	3rd year univ.	10	30	16	12
	Hons and higher	2	8	4	3
Highest	M + 2	6	7	4	6
professional	M + 3	70	51	29	67
qualification	M + 4	20	36	67	24
	Other	4	6	0	4
Years of	3 or less	6	13	12	7
experience in	4–10	58	58	21	56
teaching	11–20	30	19	38	29
Mathematics	21–30	6	6	21	7
	Over 30	0	4	8	1

More than half of the responding teachers had only Standard 10 (i.e. Grade 12 in current terminology) as their highest academic qualification, about one in six had first-year university mathematics, and about one in four teachers had second-year or higher level university mathematics (Table 1). Most urban school teachers (68%) had second-year or higher level university mathematics as compared to their rural and township counterparts where only 20% and 44%, respectively, were at this level (Table 1). Further analysis revealed that 93% of all teachers with only Standard 10 as their highest academic qualification taught in rural schools. The vast majority of teachers (91%) who responded to this survey were professionally qualified to teach Mathematics at the time of the survey. However, in terms of the Norms and Standards for Educators (Republic of South Africa, 2000), which requires M+4 as a minimum initial qualification for teachers who started their training in 2004, only 24% of teachers have a professional qualification (Table 1). Most teachers who responded had been teaching Mathematics for up to 10 years and about a third of teachers had 11 to 20 years teaching experience in this subject. A higher proportion of teachers at urban schools had substantial teaching experience of more than 20 years as compared to those who taught at non-urban ones (Table 1).

INSET needs

In general, when respondents were asked to indicate their greatest professional need (Section C of the STIN-LP), 40% identified teaching skills, followed by content knowledge (24%) and class discipline (21%), with assessing learners being rated last (12%). Half of the teachers preferred workshops to be held during school holidays, about a third (32%) preferred INSET workshops in the afternoons or on schooldays, and only 18% preferred weekends. Almost half of the responding teachers (46%) felt that lack of information was the greatest barrier preventing them from attending INSET workshops, followed by perceived poor quality of workshops (23%), workshops that fail to meet needs and inconvenient location (9% each). Inconvenient time and lack of motivation did not seem to be major barriers to INSET attendance.

Analysis of the specific INSET need items for Mathematics teachers (i.e. 38 items in Section B) was performed according to the approach used by Baird *et al.* (1993). All need items were classified into dichotomous groups of those perceived as needs, and those not perceived as needs. In order to facilitate this classification, the response "not familiar" was added to the response "great need". The selection of answer option A ("not familiar with this need") exceeded 5% on only five items, that is, for items dealing with computers, a constructivist teaching approach, process skills, and hands-on methods. The weighting for each response was defined by 1 = no need, 2 = little need, 3 = moderate need, and 4 = great need.

The categories of "no need" and "little need" were collapsed into a single category of "no need", and the categories of "moderate need" and "great need" were collapsed into a single category of "need". Using these new categories, and assuming expected frequencies for each response category to be 50%, goodness-of-fit chi-square analyses were performed to measure significance of the degree of need in each item. The need was considered to be significant at $\alpha = 0.05$. Mathematics teachers indicated a need for all items at the $p < 0.001$ level. The item "Use a computer to help manage teaching" was identified as a need by 89% of the teachers (being the highest percentage), and the need "Update your knowledge of the history of mathematics" was identified as a need by 64% (being the lowest percentage) (Table 2).

The need category refers to the seven categories assessed by the STIN-3 (Baird *et al.*, 1994). The seven categories embody basic skills expected of competent teachers. Needs which enjoyed greater importance were those dealing with acquisition of skills to use computers (i.e. delivering and managing instruction), motivating learners either through developing a positive attitude, or awareness of mathematics related career opportunities), using audio-visual equipments and application of mathematics in daily life (both from delivering instruction). The least support was indicated, among others, for needs related to the history of mathematics, improving content knowledge, how mathematics is used in society and teaching large classes (Table 2).

When looking at the different sections of Mathematics (i.e. geometry, algebra, calculus and trigonometry — part of Section C of STIN-NP), it was found that responding teachers stated that they were interested in learning more

Table 2 Ranked needs of all Mathematics teachers by need category, mean, standard deviation, and percentage of teachers who indicated this need. All needs were significant at the $p < 0.001$ level

Rank	Need description	Category	Mean	SD	%
1	Use a computer to help manage teaching	5	3.61	0.79	89
2	Use computers to teach	4	3.58	0.77	89
3	Motivate learners to learn Maths	4	3.57	0.86	87
4	Use audio-visual equipment to facilitate teaching in Maths	4	3.53	0.82	87
5	Identify learning objectives which specify attitudes learners need to develop toward Maths	1	3.47	0.79	88
6	Select supportive materials for teaching Maths	6	3.47	0.86	85
7	Use various forms of assessment to identify learning difficulties in Maths	2	3.47	0.82	86
8	Update your knowledge of the way in which learners learn Maths in a multicultural society	7	3.46	0.80	88
9	Update your knowledge of career opportunities for learners related to Maths	7	3.46	0.82	87
10	Apply concepts taught in Maths to daily life of learners	4	3.45	0.90	83
11	Identifying learning objectives which specify skills needed by learners in Maths	4	3.44	0.80	87
12	Employ teaching approaches that make learners teach each other (i.e., peer tutoring)	4	3.44	0.85	86
13	Conduct a field trip to help learners learn Maths better	4	3.43	0.86	85
14	Identify learning objectives which are appropriate for promoting multicultural ways of learning in Maths	4	3.42	0.79	88
15	Develop skills in recognising and correcting common misconceptions in Maths	7	3.42	0.90	84
16	Evaluate your own teaching effectiveness as a Maths teacher	5	3.42	0.87	84
17	Update your knowledge of issues in society related to Maths	7	3.41	0.83	85
18	Update your knowledge of learning to include a constructivist approach	7	3.40	0.78	85
19	Develop lesson plans which integrate Maths with other subjects	6	3.39	0.86	85

Table 2 Continued

Rank	Need description	Category	Mean	SD	%
20	Identify sources of free and locally available teaching materials for Maths	6	3.39	0.83	85
21	Update your knowledge of effective teaching approaches	7	3.34	0.87	82
22	Use an inquiry/discovery teaching approach	4	3.33	0.85	82
23	Design assessment items which assess achievement of learning objectives	2	3.32	0.91	82
24	Employ teaching approaches where you are able to concentrate on teaching individuals	4	3.31	0.91	82
25	Identify learning objectives which specify knowledge needed by learners in Maths	1	3.31	0.89	80
26	Select commercially prepared teaching materials	3	3.28	0.95	80
27	Use hands-on teaching methods	4	3.27	0.96	79
28	Employ teaching approaches for teaching large classes	4	3.26	1.01	78
29	Maintain learner discipline in your Maths class	5	3.26	1.06	77
30	Develop own teaching materials	3	3.21	0.91	78
31	Demonstrate manipulative skills	4	3.20	0.98	75
32	Update your knowledge of how Maths is used in society	7	3.18	0.95	77
33	Develop lesson plans	3	3.10	1.02	74
34	Improve your content knowledge	7	3.10	1.02	72
35	Organise and manage physical space in class	5	3.06	1.04	72
36	Demonstrate process skills	4	3.06	1.03	72
37	Develop lesson plans which incorporate the history of maths	1	3.00	1.02	68
38	Update your knowledge of the history of maths	7	2.89	1.05	64

about geometry (42%) and calculus (29%). However, they were not interested in learning more about trigonometry (8%) and algebra (5%). Sixteen percent of teachers indicated that they did not need help in any section of mathematics.

Possible associations between different teacher variables (i.e. age, sex, teaching experience, academic and professional qualifications) and each need were investigated by chi-square analysis. However, no significant association between teachers' individual INSET need items and any demographic variables were found.

Nineteen INSET needs were identified through focus group interviews, and

all 19 were covered by STIN-NP items in Section C. Of these 19, six appear among the top-10 ranked needs identified from STIN-LP data (i.e. apply mathematics concepts to daily life, motivate learners, identify attitude objectives, use audio-visual equipment, use computers to teach and update knowledge of career opportunities). Needs mentioned in the focus group interviews thus matched those obtained through the STIN-LP survey. Teachers' comments in the free response section of the questionnaire only emphasised some of the INSET needs already listed in the STIN-LP questionnaire and thus did not indicate additional INSET needs.

Discussion

Studies on INSET needs of science and Mathematics teachers have been conducted in several countries, for example, in the United States (Baird *et al.*, 1993; 1994), Lebanon (Jbeily & Barufaldi, 1985), Jordan (Zurub & Rubba, 1983), Malaysia (Abu Bakar, 1986), England (Dillon, Osborne, Fairbrother & Kurina, 2000), and Swaziland (Lubben, 1994). In South Africa, despite several indications of the necessity for a study on Mathematics teachers' needs (Ashley & Mehl, 1987:26; Bagwandeen, 1993; Cantrell, 1995; De Feiter & Thijs, 1996), such a study has not been conducted. The study described here fills this obvious gap in knowledge about secondary school Mathematics teachers in Limpopo province.

Findings in this study indicate that older, more experienced teachers of Mathematics are found in urban schools rather than in township or rural schools. Moreover, urban teachers are better qualified — academically and professionally — than their rural and township counterparts. In general, mathematics teachers who responded to this survey are under-qualified in terms of their academic level in mathematics and teach in rural schools. These teachers are less than 40 years old with comparatively limited experience in teaching the subject. As a result, they may find themselves in a difficult position to carry out their classroom responsibilities effectively. INSET programmes should target this group of teachers as they are likely to remain in the system for another 15 to 20 years. While it is acknowledged that the initiatives of the Department of Education over the last few years in funding cohorts of appropriate teachers — such as the majority of teachers profiled in this study — to complete the National Professional Diploma in Education and Advanced Certificate in Education (ACE) programmes have been fruitful (Department of Education, nd a; nd b; 2005; 2006; 2007; 2008), ACEs are mostly offered for teachers of subjects in the GET band. However, as the results of this survey show, one third of Mathematics teachers teach only at the FET band. These senior secondary teachers' professional development is therefore not necessarily addressed by the ACE programmes, and other professional development opportunities need to be developed for these teachers.

An area of great concern is the academic and professional qualifications of Mathematics teachers who responded to this survey. Most teachers are academically under-qualified and professionally ill-prepared for their classroom responsibilities as they have Standard 10 (i.e. grade 12) as their highest academic qualification with a three-year teaching diploma. In addition, it is

widely acknowledged that teachers at rural schools have to contend with poor resources and inadequate supply of textbooks. INSET programmes should aim at helping these teachers by specifically upgrading their content knowledge and teaching skills (i.e. their greatest professional need).

Poor communication of INSET activities was reported to be the greatest barrier to INSET participation. This implies that teachers should be informed well in advance of planned INSET activities in order to ensure maximum participation, and the programmes should also be of high quality, and at a convenient location and time. INSET programmes should also be accredited as part of fulfilling a particular qualification to motivate teachers to participate in them.

Teachers who responded to this survey perceive that they require help in all INSET need items listed on STIN-LP. However, motivating learners emerged to be their most important need. INSET programmes should therefore be designed around helping teachers to motivate learners to learn Mathematics along with other identified important needs (e.g. application of mathematics in daily life, developing a positive attitude towards mathematics, etc.), geometry, as well as around their greatest professional need (i.e. teaching skills). Unless needs that teachers consider more important are met first, even the best-designed high quality INSET programmes may fail to attract them.

Conclusion

Although the findings in this study are not representative of all Mathematics teachers in Limpopo, they nevertheless provide a useful indication of the demographic profile and perceived INSET needs of a large group of Mathematics teachers in this province. It is therefore hoped that INSET providers will make use of this information in order to plan effective, efficient, and sustainable future INSET programmes for Mathematics teachers. We are of course aware of current policy initiatives that focus on the professional development of South African teachers in general (e.g. a new Continuing Professional Teacher Development system [Republic of South Africa, 2007), and hope that the results of this study facilitate these initiatives in a meaningful way.

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Notes

1. Specific individual analyses were performed on items in which variables of interest were all responded to. As some questionnaires had missing responses, the total number of teachers in the sample therefore varies between 552 and 511.
2. The total number of schools covered is more than 324 as a number of respondents either did not fill in the school's EMIS number, or the number was incomplete. In such cases, schools could not be identified.

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