Title	Mathematics teachers' perceptions of their preparedness for teaching
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Source	*The Mathematics Educator, 4(1),70-82*
Published by	Association of Mathematics Educators

The Mathematics Educator
1999, Vol. 4, No.1, 70-82

MATHEMATICS TEACHERS' PERCEPTIONS OF THEIR PREPAREDNESS FOR TEACHING*

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Abstract

This paper reports the results of a survey carried out among secondary Mathematics teachers regarding their perceptions on their teacher preparation. The teachers were graduates from local or foreign universities who had undergone the one-year postgraduate diploma in education course at the National Institute of Education in Singapore. The survey was conducted one to two years after their pre-service training. The findings showed that majority found the teacher preparation useful but there were certain topics in mathematics or certain approaches where they would like to have further training. Interviews with experienced mathematics educators in supervisory positions were also carried out to provide qualitative data on the pre-service preparation of mathematics teachers and the findings of the interviews are also summarised in the paper.

Introduction

Secondary school teachers in Singapore are normally certified for teaching by undergoing a one-year Postgraduate Diploma in Education (PGDE(Sec)) course at the National Institute of Education (NIE) which is the sole teacher training institution in Singapore. These teachers are selected by the Ministry of Education before entering teacher training and will be employed in the centralized school system of Singapore upon graduation. During the one-year course, the trainee teachers receive pedagogical training in two subjects which they will teach at secondary level or junior college (i.e. form six or senior high) level. Majority of these PGDE(Sec) students are graduates from the two universities in Singapore, namely the National University of Singapore and the Nanyang Technological

* The research was funded by the ARF, NIE, Nanyang Technological University, RP18/94 LTSK

University. There is a substantial minority from universities in the United Kingdom, the USA, Australia and New Zealand.

For mathematics teachers, the trainee teachers are normally Science, Arts or Engineering graduates who have read mathematics in their undergraduate courses. It is assumed that their mathematical knowledge should be sufficient for teaching in secondary schools and the PGDE(Sec) Course does not include separate courses in mathematical content. However, it is clear that their teacher education goes beyond the one academic year professional training course as their mathematics knowledge is acquired through their own university and preceding mathematics education.

As teacher educators preparing pre-service teachers for teaching Mathematics at Secondary level, the authors were concerned with the effectiveness of mathematics methodology courses at the NIE in preparing the PGDE(Sec) students for teaching. We were also concerned with the students' prior competency in their subject area of mathematics which would affect their effectiveness as teachers. In Leitzel et al [1991], recommendations for the mathematical preparation of teachers of mathematics called for the enabling of mathematics teachers to (i) learn mathematical ideas, (ii) connect mathematical ideas, (iii) communicate mathematical ideas, (iv) build mathematical models and (v) use technology. The achievement of objectives (i), (ii) and (iv) can hardly be achieved through the short one-year professional course which must necessarily build on the trainee teachers' previously acquired mathematical knowledge, views of mathematics, habits of mathematical thinking, etc.

In this context, two problems faced by the mathematics educators who were training these students are discussed here. Firstly, many of these graduates had the perspective that mathematics consisted of a rather inflexible set of rules and procedures which pupils had to master and apply. During the pre-service methodology course, the lecturers tried to expose the trainees to a different perspective of what mathematics was with special emphasis on teaching for conceptual understanding. Trainee teachers were also encouraged to use activity-based and motivating approaches which were aimed at meaningful learning by students. However, as observed by Jones [1995], there was tension between teaching for understanding of concepts and teaching how to use a variety of procedures and rules. In our observation of mathematics teaching, the two aspects were seen by teachers to be competing with rather than complementary to each other. It was also observed that although the trainees seemed to be initially "converted" to such methods of teaching, many soon reverted to teaching for

procedural knowledge. They considered the former methods as impractical, giving reasons that ranged from lack of time, syllabus constraints and examination pressures to lack of resources or the inability of their particular "weak" students to learn concepts.

Secondly, Jones [1995] also pointed out that "teachers with deeper understanding of mathematics tend to tailor their teaching to more conceptual views and that teachers with a lesser knowledge of mathematics tend to use a more rote structure", an observation which is also true in our experience of supervising trainee teachers in Singapore. This observation is certainly not intended to place harsh judgment on the teachers. In fact, it may be the lesser of two evils as correct rote learning of rules is preferable to the little or wrong understanding of concepts resulting from unsuccessful attempts to achieve meaningful learning. Although some trainees gamely tried out the newly learnt approaches, correct meaningful learning of concepts often did not take place. This was because the more flexible teaching/learning style required skillful guidance and monitoring by the teacher to achieve its objectives and the trainees' lack of experience or their own inadequate understanding of the mathematical concepts could result in ineffective lessons.

The mathematics methodology course of the PGDE(Sec) had been evolving through the eighties to focus on more applied aspects of teaching various topics rather than mainly emphasizing theories of learning and expecting the trainees to apply such theories in the school situation. In an effort to encourage more self-learning and higher understanding by the trainees, the course was re-structured in 1993 for the 93/94 academic year and a description of this is given in Lim & Yap [1996]. Although course evaluations at the end of each academic year were positive since the late eighties, there was no data on how effective the training was after the trainees had graduated from the institution. This research study, which began in December 1994, thus set out to examine secondary mathematics teachers' perceptions of their preparedness for mathematics teaching in the areas of (a) their content knowledge, (b) their professional pre-service training and (c) needs for further professional development in the area of mathematics.

Instrumentation and Sample

A survey form consisting of 3 sections was used to gather the data. In Sections A and B, there were 4 statements and 7 statements respectively where the respondents had to rate their agreement or otherwise on a 5 point scale as well as 1

additional open-ended question for their inputs in each section. Section A of the form dealt with mathematics studied at the university level and the extent to which university level mathematics was useful and relevant to the respondents as mathematics teachers. Section B sought the respondents' views on the pre-service training during their PGDE(Sec) Course with special emphasis on the mathematics methodology course. Section C consisted of 3 open-ended questions which sought the respondents' feedback on their training. (A copy of the survey form may be obtained on request).

The sample consisted of all graduates of the PGDE(Sec) Course who underwent the Mathematics Methodology course in the cohorts of the 92/93 and 93/94 academic years. The reasons for choosing these cohorts were as follows:

(1) Undergraduate and professional courses would be fresher in the minds of those who graduated rather recently.

(2) As the study was carried out in mid-1995, these teachers would have had some one to two years of teaching experience after their training and would be able to assess the relevance of their courses in the light of such experience.

The survey was carried out by posting the forms out to the teachers using last known addresses according to the records at the NIE. The teachers were assured that their responses would be kept confidential and they were not required to put their names on the form. Stamped and addressed envelopes were also enclosed. The response rate was low, which is not unexpected for this type of survey. The number of survey forms sent out and the number returned are given in Table 1 below.

Table 1: Response Rate

Cohort	No. sent out	No. returned	% Return
92/93	132	27	20.5%
93/94	303	71	23.4%

After the analysis of the results of the survey, interviews were carried out with five experienced mathematics educators to find out their views regarding expectations of competencies of newly-trained mathematics teachers and further development. The three questions asked were basically (a) whether they found the

mathematics teachers adequate in content knowledge and methods of teaching, (b) whether they felt that the methods advocated by the training institute for developing concepts etc. were impractical as the teachers maintained and (c) what in-service courses would benefit mathematics teachers.

The five interviewees are identified as A to E. All the five have had experience teaching mathematics as well as supervising teachers of mathematics. A is a principal who has also been a vice-principal and a head of mathematics department. B is a vice-principal who has had more than 10 years of experience as a head of mathematics. C has been a head of mathematics department at a secondary school for more than 5 years. D has been a co-operating teacher supervising teacher trainees at a secondary school and, at the time of interview, was at the Ministry of Education where his work involves visiting mathematics teachers in a supervisory as well as mentoring role. E is also from the Ministry of Education where her work involves supervising, mentoring as well as co-ordinating professional activities of mathematics teachers.

Findings Regarding Trainee Teachers' Mathematics Education at University

For Section A on mathematics studied at University level, there were 4 statements and Table 2 below gives the statements and the percentage of the respondents in each of the categories Strongly Disagree, Disagree, Neutral, Agree and Strongly Agree. The total number of forms returned was 98. Not all respondents answered all the items and for each of the items of Section A, the total number of responses was 95.

Table 2: Percentages of Responses in the 5 categories for the Statements on University Mathematics

	Statement	SD	D	N	A	SA
A1	University Math provides me with a better understanding of the Math concepts which I teach.	4.2	27.4	22.1	33.7	12.6
A2	University Math enables me to understand more clearly what Math is all about.	3.2	12.6	24.2	43.2	16.8

Table 2 (... cont'd)

	Statement	SD	D	N	A	SA
A3	The Math I studied at university inspired me to love the subject.	9.5	26.3	26.3	24.2	13.7
A4	I feel inadequate in some areas of Math at the secondary level.	21.1	29.5	19.0	26.3	4.2

As the Mathematics Teachers' content knowledge and attitude towards Mathematics were mainly established before their pedagogical training, the findings from Section A throw some light on the entry attributes of the pre-service teachers. From responses to A1 and A2, it can be seen that University Mathematics provided 46% of them with a better understanding of the mathematical concepts which they now teach while enabling 60% of them to understand the discipline itself better. As the content Mathematics studied at the University was supposed to provide grounding in the discipline, it is worrying that less than half of these Mathematics teachers find their University Mathematics education helpful in the concepts they now had to teach. It must also be noted that the range of Mathematical backgrounds of the teachers is great, from first class honours in mathematics to a year or two of general mathematics and those who have done little University Mathematics and those who have not achieved good grades may well have learnt and understood little Mathematics during their undergraduate course. This points out that a better understanding of mathematical concepts required for teaching at the Secondary School Level cannot be entirely achieved through some undergraduate courses in Mathematics.

The responses to statement A3 showed that only 38% were inspired by higher level Mathematics to love the subject. Although Mathematics has always been a subject which inspires awe but not love, as evidenced from literature on attitude towards Mathematics, the sample is not from the general public but consists of teachers who have chosen to read Mathematics at tertiary level and have chosen to be Mathematics teachers. As one of the important attributes of an effective teacher is his/her enthusiasm for the subject, it is not encouraging that the majority among these mathematics teachers have not been inspired by their own mathematics education.

As for the teachers' content preparedness, the responses to A4 showed that 30% agreed or strongly agreed with the statement of inadequacy. The written responses showed that the teachers felt inadequate in only a few topics and the

topics which occurred more often in the responses were the more conceptually difficult topics such as probability, statistics, vectors and mechanics. From some responses, it was clear that some of the teachers had not done these topics in their own mathematics education. Although the statement referred to secondary mathematics, some respondents noted inadequacy in areas covered in 'A' level Mathematics such as calculus and trigonometry. Two also noted the area of problem-solving which is the emphasis of the new syllabus. Perhaps this is not related to University Mathematics but to the teachers' concern with their own ability to solve non-routine and unfamiliar problems as they have been used to a more procedural and algorithmic approach.

Findings Regarding Pre-service Teacher Education

For Section B on the professional pre-service training, there were 7 statements, B1 to B7 and Table 3 shows the agreement with these statements in percentages of total number of responses. Again, not all the 98 respondents answered all the items and the total number of responses for each statement in Section B ranged from 96 to 98.

Table 3: Percentages of Responses in the 5 categories for statements on professional pre-service training

	Statement	SD	D	N	A	SA
B1	I feel that the methodology course was useful to a beginning teacher.	2.0	5.1	11.2	64.3	17.4
B2	Pre-service training should include content mathematics as well as methodology course.	3.1	12.4	14.4	45.4	24.7
B3	I was able to apply general education courses (not math methodology courses) to the teaching of mathematics.	6.3	7.3	13.5	63.5	9.4
B4	The methodology course has prepared me well to teach mathematics.	3.1	9.2	32.7	46.9	8.2
B5	I feel inadequate in choosing effective approaches to teach mathematics during my teaching experience.	4.1	29.6	30.6	33.7	2.0

Table 3 (... cont'd)

	Statement	SD	D	N	A	SA
B6	The methodology course provided insight into the meaning of mathematics.	5.1	14.3	20.4	51.0	9.2
B7	I feel that the methods/approaches learnt in the methodology course are not practical in the real school situation.	5.2	28.1	28.1	30.2	8.3

The findings showed that a great majority found the course useful (B1) and were able to apply the general education courses to their teaching (B3). From the responses to (B6), it can be seen that the majority gained insight into what mathematics was about. However, from (B4), although only 12% felt that the methodology course had not prepared them well to teach, 33% were neutral to that statement, leaving 55% who thought that the methodology course prepared them well for teaching. Responses to (B5) confirmed this, where more than one-third of the respondents agreed that they felt inadequate in choosing effective teaching approaches.

From informal feedback, it seemed that teaching approaches and methods which are based on learning theories have been regarded by practicing teachers as time-consuming and impractical in the actual classroom situation and as only advocated by academics and not practitioners. From the responses to B7 regarding the impracticality of the methods advocated, this view was held by about 38% of the respondents. About a third disagreed with the view and the remaining 28% were neutral. When the respondents who felt the methods were impractical were asked to elaborate, from the 40 responses, 25 mentioned "time constraints" or lack of time for preparation. They felt that within the tight syllabus constraints, it took too long to teach for relational understanding[1] and meaningful learning as opposed to teaching for procedural knowledge. Quite a few also mentioned that the methods were unsuitable for weaker students, implying that only better students could see the connections and meanings.

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[1] Relational Understanding is the term meaning understanding not only how to apply rules but why they work. See Skemp [1976].

The last question of Section B, B8, was open-ended, requesting respondents to suggest in-service methodology courses which may be relevant or useful to them. The responses to this question also provided evidence that beginning teachers sought more training in certain areas of their teaching and these included effective teaching strategies in an assorted list of topics, especially higher level topics, and methods for teaching weaker and unmotivated students.

Findings from the Open-Ended Questions

The survey also sought the respondents' views on which parts of the methodology course they found most useful (Question C1) and which they found least useful (Question C2). From the 82 who responded to Question C1, five areas emerged as the most useful: (a) twenty-one mentioned various practical approaches and teaching ideas for different topics, (b) sixteen mentioned the practice teaching sessions, (c) fifteen mentioned problem-solving, (d) thirteen mentioned misconceptions in various topics and (e) thirteen mentioned the group discussion-cum- presentations learning approach which was used with the 1993 cohort. It could be seen from the responses that methods which could be used directly and feedback on their teaching skills were considered useful. In the 1993/94 restructuring as mentioned in the introduction, group work and self-reliance was increased greatly in that the trainees had to read, discuss and present certain aspects of teaching the 5 main topics of Algebra, Geometry, Statistics, Calculus and Trigonometry. It is noteworthy that 13 of the 71 respondents from the 1993 cohort mentioned the approach as useful in their pre-service training.

For the answers to Question C2, ten respondents mentioned that they did not find the learning theories useful. This is not surprising as informal feedback from teachers often show that they prefer practical methods rather than theories on how students learn. They do not see the theories as foundations upon which to base their teaching methods but prefer ready-made recipes for teaching various topics.

In response to C2 and C3 which asked for suggestions for modifications of the methodology course, some respondents mentioned areas which they felt deserved more coverage. The two main areas were Assessment and Teaching at the Junior College (Senior High) level. Another suggestion for improvement from two respondents indicated having the course interspersed with actual teaching practice in school in order that the theories made sense and for more help to be given regarding "real" situations in the classroom. It should be explained that the PGDE(Sec) programme structure has a Teaching Practice block of 10 weeks after

all coursework is completed in slightly more than one semester. Another suggestion is for more classroom observation of experienced teachers in action and sharing by these teachers. The last two suggestions are extremely sound but difficult to implement on the large scale given the present status of partnership between the university and schools in pre-service teacher education.

In response to the last question on a more structured in-service programme of several modules spread over 2 years, only 25 of the respondents replied in the affirmative. Others preferred either short courses or very few modules. Two were skeptical as to the usefulness of such courses and another even said that pre-service training was sufficient. Nine respondents mentioned heavy workload of teachers and responded that teachers attending such a course should be given time off or off-loaded from their duties at school. A few were positive but regretted that they would not be able to attend due to varying reasons such as "no longer teaching mathematics", "domestic commitments", "attending other courses for heads of department", etc.

Interview Results

The findings from the interviews can be discussed under three areas: (a) the content knowledge of the mathematics teachers, (b) the apparent contradiction between student-centred learning and the needs of the schools and (c) further professional development of mathematics teachers.

All five interviewees found that the mathematics content of the teachers was adequate. However, they also felt that it was important for the methodology course to include discussion of content of the school mathematics syllabi. The reasons for such a necessity varied. B and E both felt that some teachers needed a refresher on the topics. B mentioned male teachers who because of national service have left doing school or junior college mathematics for several years while E mentioned teachers for whom mathematics is their second subject. D saw that teachers from different university courses, for example mathematics and engineering graduates, approached mathematics differently and they all needed a greater understanding or wider perspective of the philosophy and spirit of mathematical thinking. Both C and E said that teachers who are stronger in their own content were able to explain more clearly because of their own understanding.

When asked to comment on the perception that the student-centred approaches advocated in the methodology courses were impractical in the school

system, A, C, D and E did not agree with that view. Both A and D did agree that from their experience, the syllabus is rather heavy and teachers feel rushed to complete the materials. However, although it was important to "cover the syllabus", both A and C felt that teachers could, in C's words, "strike a balance between finishing the syllabus and using more innovative methods [of teaching vs drilling the students in the use of formulae]." As A puts it, "With good planning, good time management in the classroom, I believe it can still be done." C mentioned that such management may be more difficult for new teachers as they have many adjustments to make.

As many of the respondents had mentioned that they needed more training in the current problem-solving approach of the curriculum, the interviewees were also asked their perception on this. E said that as someone from the Ministry of Education, she was impressed that the course was in line with the current emphasis of the curriculum as developed by the Ministry of Education. "I would say that if I had gone through a course like that, I would be fairly well-prepared for teaching in schools." While C and D felt that it was the newer teachers who were more willing to try the problem-solving approach, E felt that the style of teaching depended on the varying culture of the schools and that there were some schools which were still very traditional in their style of teaching mathematics. Principal A felt that anxiety about such approaches was normal as teachers had to adjust to the role of being facilitator and not the person with all the answers. Most of them agreed that there was pressure from examinations and C also mentioned that they have tried to set examination questions to include more non-routine problem-solving since the Singapore school climate is still rather "exam-driven".

One of the reasons why new teachers found student-centred approaches impractical is that they do not have quantitative evidence as to whether such methods would work. E mentioned that there needed to be much more sharing by experienced teachers so that the newer teachers would know the real constraints and, rather than simply throwing out such approaches, they would then implement the approaches with proper consideration for these constraints.

On further professional development, a few of the interviewees, viz. A, C and E, mentioned sharing among teachers and school workshops. Special in-service courses for junior college teachers were also suggested by B and E as the present range of courses seem to cater mostly for primary and secondary school teachers. Both C and E mentioned that there needed to be more trying out of methods and teachers should then report on and discuss the success/failure of such methods. Such a structure would be more beneficial than courses which cover a great deal

and are assessed by tests rather than by experience. A and D also regarded sharing sessions and networking among mathematics teachers as important for professional development.

Conclusion

Course evaluation has always been carried out at the end of the PGDE(Sec) Mathematics Methodology course year after year and the feedback has usually been very positive in that the trainee teachers found the course useful. The results of the present study show that there is much more to be done, either in meeting the needs of the teachers or in sharing better with them the philosophy of mathematics education which seems to be at odds with the demands of the system.

Since the 1993 revision of the methodology course, a conscious effort was made to include in each topic a serious discussion of difficult mathematics concepts within the topic. From the results of the survey, it appears that this area merits a greater emphasis even within a methodology course and the assumption that graduates with university level mathematics have a *sufficient* understanding of mathematics concepts in order to teach secondary mathematics and should therefore *only* need methodology is flawed.

These findings also show that newly trained teachers do not see the pre-service as merely foundational where their capabilities would be further developed through experience and in-service courses. More should be done to make explicit the competencies expected of newly trained teachers and further professional development with regards to additional competencies should also be mapped out. Such development maps should be worked out together by all parties concerned i.e. the training institution, the employer (in Singapore's case, the Ministry of Education) and the schools and should also be clearly communicated to the teachers.

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