

Teacher as Researcher: A Review on Mathematics Education Research of Singapore Teachers

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Abstract: Teachers interested in improving teaching and learning are potential researchers for they are in the best position to ask questions and collect data for analysis about student learning. This review focuses on 101 research studies done at the National Institute of Education by Singapore teachers as dissertations and theses presented for postgraduate degrees from 1991 to 2005. The objectives of this review are to provide a perspective of current development and practice in teacher research in Singapore and identify important variables that should be considered in future research. This will have implications for extending the body of knowledge in mathematics education and stimulating more research in the decade ahead.

Key words: Mathematics teacher research; Singapore mathematics education; Review of mathematics education research; Graduate studies

Introduction

Mathematics education research in Singapore can be said to be at a youthful age for its relatively short history, judging by the first ever *State-of-the-Art Review* by Chong, Khoo, Foong, Kaur, and Lim-Teo (1991) which surveyed the status of local research over a decade in the 1980s. They located only 42 studies from research reports, theses, dissertations, journal articles and proceedings of conferences. Now 15 years on, the amount of research in mathematics education in Singapore has grown steadily especially in classroom investigations by school teachers. The focus of this paper is to review a sample of 101 mathematics education research reports presented as dissertations by mostly Singaporean teachers for their postgraduate degrees at the National Institute of Education (NIE). NIE is the sole teacher training institute in the country whose mission is to excel in teacher education and educational research. There is an emerging trend here in teacher professional development amongst practicing teachers to pursue Masters programmes for the opportunity to learn about and do research. According to Hart (1998) mathematics education research is normally pursued through three routes: (a) as part of postgraduate studies by a master or doctoral student, (b) as part of the expected work of an academic, and (c) within the profession of researcher. In choosing to analyse postgraduate research of teacher practitioners in the Singapore context, the aim is to gather a snapshot of the range of research interests amongst teachers that might give an indication as to whether these research inquiries are driven by teachers' concerns about day-to-day classroom events or by emerging curriculum

reforms set off by the various Ministry of Education (MOE) initiatives in the current mathematics education scene.

Teacher as Researcher

In order for research to be effective that can help schools to improve quality of education, it would seem that teachers should be part of the process of research to enable them to have direct access to the outcomes. In the current climate of reforms that call for teachers to be agent of change in improving the student learning in mathematics, teachers are in the best position to investigate and record aspects of their teaching, their classroom and their students that are normally hidden from the others. It is said that when a teacher becomes a researcher in her or his own classroom it will add a vital dimension to his or her teaching and student learning. When a teacher reflects in action and asks questions, he or she becomes a researcher in the practice context. “Why didn’t they understand...”, “How and what can I do to help them learn....?”, “How did my teaching actions affect what happened?”, “What would happen if ...?” Such reflections could naturally be formulated into research queries.

Hatch and Shiu (1998) cautioned that if mathematics education research were done solely by mathematics educators or researchers, then there was a danger of the isolation of research from teachers and its value could not be realized. They observed that teachers as researchers were motivated by the need to construct their own knowledge about the things that were important to them. They were also in the unique position to ask questions about learning, to accumulate data and to take up teaching directions based on the learning pattern that emerged. Teachers were doing research when they formalized to bring a sense of rigor to their inquiries with carefully designed questions and hypotheses to carry out the investigation. Since they had in-depth and intimate contact with their own classrooms, the findings and knowledge gained from their research could be directly and readily shared with other teachers.

Currently many schools in Singapore are encouraging their teachers as part of professional development to implement personal or team action research projects. Teachers have taken advantage of the opportunities offered by classroom research and there has been much sharing of such work among the community through conferences and cluster workshops.

The Study

The review of mathematics education research reported here focused on research studies done for Master and PhD degrees mainly by Singapore teachers at the

National Institute of Education. This only provided a partial view of the bigger picture of all the mathematics education research that had been done in Singapore. For the present study there were two objectives:

- i. to provide graduate students and mathematics educators a perspective of current development and practice in teacher research done as postgraduate studies in Singapore;
- ii. to identify some important variables that should be considered in future research.

Method

It had been queried: “Can Master of Education dissertations qualify as research?” For this study the reviewer adopted the position held by Hatch and Shiu (1998) that teachers were empowered to do research as part of their postgraduate studies for they were in the right position to examine the questions of their own practice and meanings that arose in their classrooms. Carrying out the research and writing the dissertation was a form of disciplined inquiry. Hatch and Shiu defined research in mathematics education as:

the intentionally controlled examination of issues, within and related to learning and teaching of mathematics , through a process of inquiry that leads to the production of (provisional) knowledge both about the objects of the inquiry and the means of carry out that inquiry (p. 297).

Currently at the National Institute of Education (NIE), the Master of Education (MEd) programme is offered to practicing teachers as a coursework cum dissertation degree (since 2003, candidates can also opt to do a full coursework programme). For the dissertation, teachers are required to undertake an extended piece of explicit classroom research under the supervision of an academic professor. They identify a problem, examine relevant literature, carefully formulate the research question(s) and consider the form of data collection that is open to them. Many of the studies are of essentially small scale, working with intact classes and drawing on the experience of teaching. Collectively they can form a resource of potential richness, which might be of use to others. These are examples of carefully planned investigations based on a body of research and implemented to investigate the teaching and learning of mathematics in Singapore classrooms.

A search of the NIE library website, <http://www.acis.nie.edu.sg/libris>, for the repository of local Master and PhD theses over the period 1991 to 2005, generated a total of 101 relevant abstracts on mathematics education research. To categorise

these research studies for analysis of important variables in the mathematics education domain, this report followed the framework used by Walshaw and Anthony (2004) in their review of Australasian research. They recognized the wide range of topics, emerging new perspectives and approaches characteristic of the vibrant domain in mathematics education research. In their review they portrayed the domain by content, issue, participant, style and data. In a similar way for categorization of the local dissertations in this study, the reviewer classified them according to the content areas and issues that were of interest to teacher researchers in Singapore. This was followed by categorization according to the types of participants that were being researched, within what context and the research methods employed.

Number of Graduate Research Studies through the Decades

Before presenting an analysis of the research studies in the next section, the reviewer charted the growth of postgraduate research in Singapore since the last review by Chong et al. (1991). That was the first ever review of all mathematics education research in Singapore by the end of 1980s. There were only 42 studies starting from 1979 to early 1991. Out of these 42 studies, only 15 were MEd dissertations and one PhD thesis. For the present period of review from 1991 to 2005, just for postgraduate theses and dissertations there were 101 located in the NIE library. All Master dissertations and PhD theses completed at NIE were indexed and copies displayed in the library. This search for Singapore teachers' postgraduate research studies could not claim to be exhaustive for it did not include those studies that were done outside of NIE. Based on these data, Figure 1 on next page charted the growth of postgraduate research in decades from the 1980s to the early 2000s.

Compared to the number of studies conducted in the 1980s, it showed a great increase in the number of teachers who had pursued post-graduate studies, mainly in Master of Education (MEd) with a handful of the Master of Arts (MA) research. These were undertaken as part of their professional development and to gain experience in doing research. By the first half of this decade, that is, for the period 2001 to 2005, there were 69 Master dissertations and 6 PhD theses, a great jump from 25 Masters and 1 PhD in the previous decade. As to the average length of time taken to complete the MEd coursework cum dissertation degree, the data obtained from 53 candidates gave an average of 3.3 years. Very few graduate students took as short as 2 years and some took as long as 6 years to complete their graduate programmes.

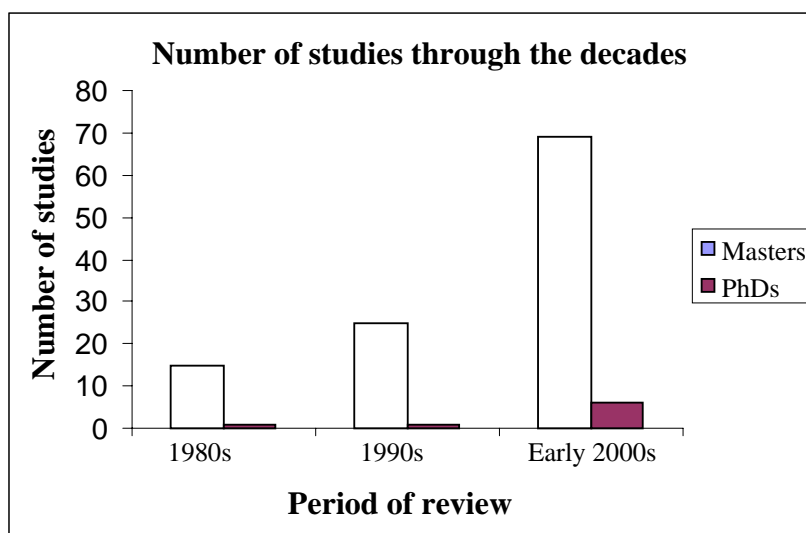


Figure 1. Growth of the number of Masters and PhD studies

Variables in Postgraduate Research

After having read through the 101 research reports, the reviewer organized the categorization of each research across five variables in the mathematics education research domain and their sub-divisions. The five variables were listed below: i) research participants, ii) level of schooling, iii) mathematical contents, iv) educational issues, and v) research methods. For each of these variables, a descriptive profile is presented and special mention is given to some reports as examples.

Who are the research participants?

By research participants it was as defined the people whom the study was being effected upon. They would include students, teachers and, or people (if any) from the community such as parents. However, since the researchers in all the studies under review were mostly school teachers so it was natural that students formed the majority of the research participants, as reflected in Figure 2 (see next page). 93% of the studies used participants who were students in primary schools, secondary schools and junior colleges.

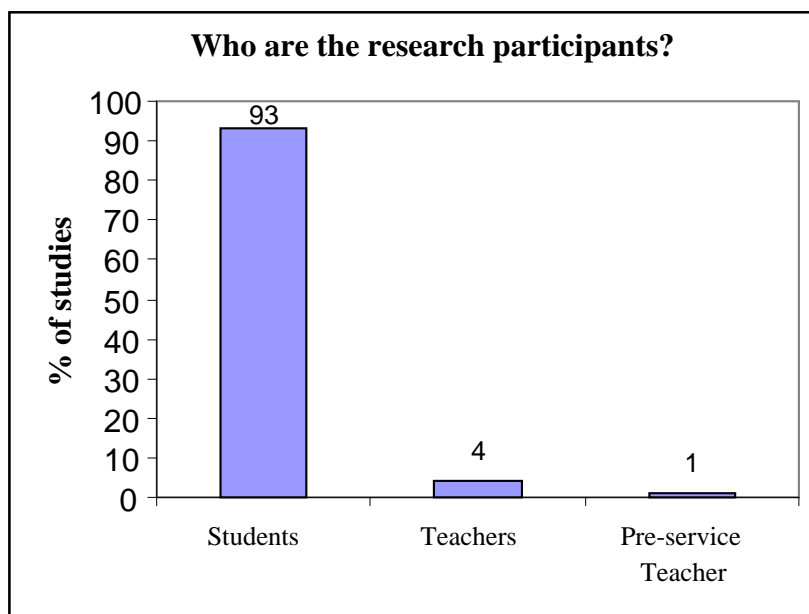


Figure 2. Percent of studies by participant groups

Many of the student groups in the studies were from intact classes of the teacher researchers. This was certainly valid in educational research where the focus of a teacher's inquiry should be on his or her students when their learning outcomes matter the most. Although it was not a popular culture here to study the teacher by teachers in research, there were nevertheless four studies on teachers and one on pre-service teachers in this review. Kay (2003) compared the beliefs and instructional practices of new and experienced primary teachers and found that for both groups their instructional practices were not related to their beliefs. Paraskevi (2005) investigated the relationship between high quality mathematics instruction and organizational citizenship behaviour (OCB) of 330 primary mathematics teachers and found that good mathematics teachers engaged more in discretionary favorable behaviours (OCB) towards their profession, their organization and all stakeholders than the general population of teachers.

What level of schooling as context of research?

The level of schooling where the research participants were sited was further analysed into seven contexts: primary, secondary, junior college (JC), polytechnic,

NIE and a special group of educationally subnormal children (ESN). The analysis of research context would give an indication as to where the expertise of the research community was located. However in this review, the sites would usually be where these teacher-researchers were employed and would not be representative of the general expertise located at that level. It would only indicate that if more secondary teachers were pursuing their postgraduate studies then the figure would show higher percentage of research done at the secondary level of schooling. Figure 3 shows the distribution according to level of schooling of research participants.

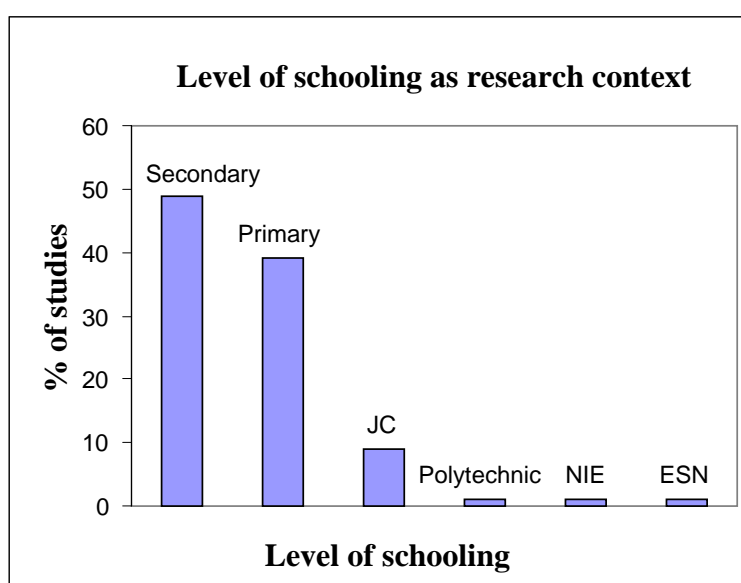


Figure 3. Percent of studies by level of schooling

Within the school sector, 49%, 39% and 9% of the studies were sited at the secondary, primary and JC level respectively. The majority of all these studies were conducted using sample sizes of one to four intact classes averaging about 36 students per class and the researchers were usually their class teachers collecting data for their postgraduate research. These studies mainly investigated students' cognition in learning or new teaching approaches and their effects on students. A study each was sited at a polytechnic and at NIE where pre-service teachers were the focus. At the ESN level Ee (1991) experimented with 40 ESN children from special schools and showed that they were capable of learning addition and subtraction through effective short-cut procedures.

What are the areas of interest in mathematical content?

Much of mathematics education research anywhere had a tradition to focus directly on learning outcomes of specific mathematical content. For the last fifteen years, the area of interest for research in the mathematics classrooms by the local teacher under this review had traditionally focused on specific mathematical contents. In all, 72% of the studies examined explicitly particular mathematical content of student learning, while 20% focused on general mathematics achievement and 8% on non-content issues like affect or gender. Figure 4 shows the breakdown percentages of studies on specific mathematical content:

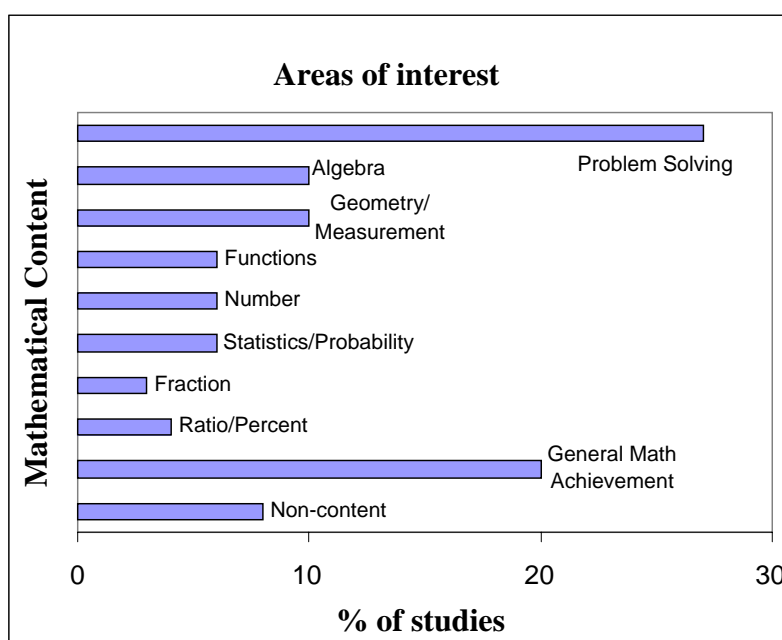


Figure 4. Percent of studies by mathematical content

Percent of studies by content were problem solving (27%), algebra (10%), geometry/measurement (10%), functions (6%), number/computation (6%), fraction (3%), statistics/probability (6%) and ratio/percent (4%). There were more than a quarter of the studies focusing on problem solving for the period of review from 1991 to 2005. It showed that problem solving had been and still was a significant area of interest and concern among Singapore teachers. Of these 27% there was an even distribution of problem solving studies between the primary and secondary

level of schooling. Although internationally, the trend on research in mathematical problem solving had waned over the years (Lester, 1994), the mathematics curriculum for Singapore schools had continued to emphasize its importance. The framework of the Singapore Curriculum (MOE, 2000) embodied *Mathematical Problem Solving* in its core. Mathematical problem solving as stated in the framework included using and applying mathematics in practical tasks, in real life problems and within mathematics. It advocated that problems should cover a wide range of situations from routine to non-routine mathematical challenges in unfamiliar context as well as open-ended investigations that required heuristics and thinking processes.

MEd studies on mathematical problem solving at the primary and secondary levels were exemplified by Ho (1997), Wong (2002), Seah (2002), Chow (2005), and Tan (2005). They were indicative of teachers experimenting with new approaches such as using co-operative learning, heuristic instruction, open-ended problems, problem-posing strategies and problem-based tasks to develop thinking skills and enhanced mathematical problem-solving performance. Of the six PhD theses, Quek (2002), Yeap (2002), Yeo (2004), and Zhu (2003) had problem solving as their focus of study. In Yeap's research he developed a scheme to classify the wide varieties of problem-posing tasks used in instruction and research, while Quek's research revealed that the meaning and motive a person had for engaging in mathematical problem posing directed the person's actions and determined its outcome. Yeo was concerned about mathematics anxious students and its effect on their mathematical problem-solving performance. Zhu did a comparative study of problem solving representations in the textbooks of Singapore, China and the United States. She found that the problem solutions presented in Asian textbooks covered just 'how to carry out the plan' in Polya's third stage, whereas the majority of problem solutions in the US textbooks were presented with at least two problem-solving stages.

Students' difficulty in learning algebra at the lower secondary level was the theme of 10 MEd studies. These studies examined students' sense-making of algebraic expressions, solving quadratic equations, their errors and misconceptions (e.g. Loh, 1991; Ng 1996; Ying, 2005). Van Hiele's learning theory of geometry was used by two out of the 10 studies on geometry and measurement to evaluate primary students in Ho (2002); and secondary as well JC students' geometric thoughts in Hang (1994). Number and fraction topics were focused but not sufficiently as these fundamental concepts were often an area of concern to the underachievers at the lower primary levels. Loh (2005) used journal writing to assess P5 pupils' understanding of fraction, while Koh (1991) did a comprehensive basic test on 465 P3 students to identify their errors and misconceptions. Topics like functions,

probability and statistics were researched mostly at the JC level to diagnose students' difficulty in learning the topics using error analyses.

Educational issues

Although the majority of the studies focused on specific mathematical content, they also served as a context for the examination of educational issues. For example, effective use of technology like GSP tools was examined in the context of transformation geometry in Leong (2001) and issues of language was examined by Chan (2003) in the context of primary students solving arithmetic word problems. Most research about teaching and learning were usually driven by some important educational issues that arose from within the everyday classroom or policies on curricula reforms. Eight constructs of educational issues adapted from Walshaw and Anthony (2004) were used in this analysis viz: *cognition*, *pedagogy*, *technology*, *curriculum*, *affect*, *equity*, *teacher* and *language*. When a research spanned across more than one educational issue (e.g. pedagogy and technology), it was categorized according to the area which the researcher gave most significance based either on the title or objectives of the research. In this way each study was coded only once. Figure 5 shows the distribution of the studies across the eight constructs of educational issues.

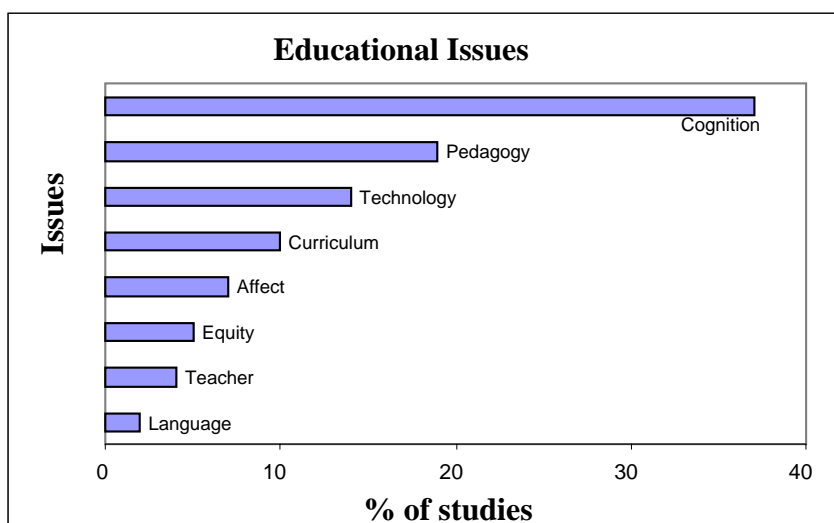


Figure 5. Percent of studies by educational issues

Student's learning outcomes in mathematical content had always been the central focus of educational research. Hence the construct, *cognition* referred to learner

effects that include students' understanding, thinking processes, problem solving strategies, learning styles, difficulties and misconceptions that were associated with mathematical contents. Analysis of results showed that the most number of studies, 37% were focused on learner's cognition. For examples, Seshadrinathan (2005) assessed 36 grade 6 students' proportional reasoning skills using ratio and proportion tasks and Teng (2002) identified the cognitive obstacles faced by P5 students in solving complex arithmetic expressions. Lee (2003) looked at the relationship between cognitive style and hemisphericity of 407 secondary mathematics achievers.

19% of the studies focused on *pedagogy* that referred to teacher effects, the results of the teacher's effort in organizing the instruction and interactions in the classroom. These studies explored alternate instructional strategies that would include use of cooperative learning, journal writing, math trail, open approach, problem posing to enhance student understanding of mathematical concepts as well as problem-solving performance. For example, Ho (1997) implemented a cooperative mathematical problem solving programme while Seoh (2002) used an open-ended approach to enhance critical thinking skills in her secondary 5N students. Although many teachers were willing to study effects of their instructional methods on their students, not many were interested in investigating the teachers themselves. That was indicated by only 4% of the studies actually focusing on the teacher in term his or her knowledge, beliefs and behaviours.

14% of the studies examined the use of *technology* and its effects in the mathematics classroom. Over the years use of ICT in teaching and learning had aroused much interest due mainly to the MOE's launch of Master Plans for IT where some \$2 billion was allocated to transform classrooms into computerized environment. In mathematics education teachers were gaining more knowledge of the availability of soft wares and tools that were designed for use in the teaching of specific topics, and they were keen to research them for student learning effectiveness. The studies associated with technology in this review had their focus spread across CAI (Computer Assisted Instruction); use of specific softwares that included EXCEL (Chan, 2001), Graphmatica (Ingham, 2000), GSP (Leong, 2001); and evaluation of a secondary school mathematics e-learning project (Lee, 2002). With the permit to use graphing calculator for the 'A' Level mathematics examination from 2006 onwards, Yen (2005) had surveyed JC students on their attitudes towards its use in the classroom.

Affect referred to attitudes, beliefs, values and emotional factors in the teaching and learning of mathematics. 7% of the studies focused on this issue. Loh (2005) identified the types of help-seeking strategies amongst secondary three students in

mathematics, Rahmat (2000) looked at secondary students' perception of the relevance of mathematics and Soh (2002) used math trails to improve the attitudes of her students towards learning mathematics.

Curriculum issues would include curriculum design, implementation and assessment. 10% of the studies were categorized under this. Two studies, Ng (2002) and Zhu (2003) research the school mathematics textbooks for representations of problem solving with the latter doing a comparative studies among three countries. Anandarajah (2002) evaluated the suitability of the foundation mathematics course for the P6 EM3 stream. Chai (2004) explored journal writing as an alternative form of assessment.

Other important issues like *equity* and *language* were research although not many. There were five studies on issues of equity relating to gender differences, race and availability of tuition as learning support. Linden-Hitchcock (1994) surveyed 3864 gifted students for gender differences in mathematics achievement while Loo (1996) found gender differences amongst her students in higher mathematical reasoning skills. In the case of Lee (2003) he looked at the learning style, gender and race of low performing mathematics students and Gan (2003) found that there was significant difference in mathematics achievement between students who received tuition and those who did not receive in a low-achieving school. Issue of language was the focus of Chan (2003) and Leong (2004); they found correlates between students' proficiency in the English Language and Mathematics Achievement.

Research style

In going through the 101 studies, there was not a wide range of research methods by way of how the data were collected. Six methods were identified: task assessment, survey, quasi-experimental, document analysis, case study and interview. As shown in figure 6, there was 66% predominance of research procedures based on test items or task assessment of student performance. The nature of the task assessment ranged from traditional test items commonly found in textbooks or worksheet to problem-based performance tasks. These test situations were often accompanied by interviews of a smaller selected sample to delve deeper into the responders' thinking. For the more open- response performance tasks rubrics were usually designed for scoring students' work. This data collection method of pre- and post tests in task assessment were used in many of the studies that related to issues of cognition for learner effects and effectiveness of certain pedagogy which the teacher researchers had implemented. When task assessment style of research used an experimental design for one group to be compared to a control group, such research style was categorized as quasi-experimental. 9% of the studies used a quasi-

experimental method involving at least two intact classes within the same level in a school. Use of questionnaire survey was found in 16% of the studies. About 10% of the studies used sample size of more than 500 students, with special mention of Lenden-Hitchcock (1994) who surveyed 3864 secondary students for gender differences in mathematics achievement; Lim (1993) surveyed 1028 secondary students to find from them the qualities of good mathematics teachers. Such quantitative research method is not common among the MEd studies in the early 2000s where small scale intact class samples were often used to generate qualitative data of students' process skills and communication through task assessment.

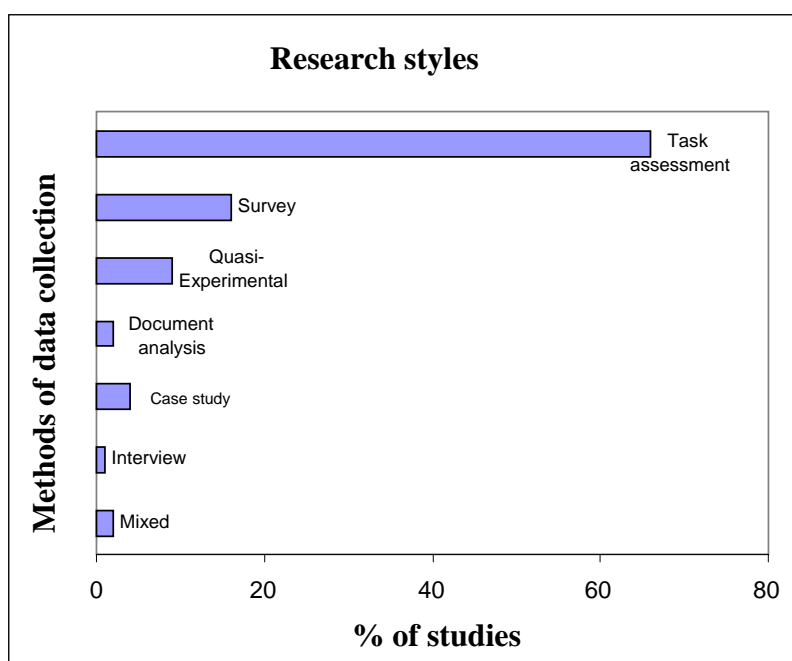


Figure 6. Percent of studies by research style

Other research methods like interview was found in one study where Bay (2004) interviewed students for their interpretation of statistical graphs. Kay (2003) did interviews and classroom observations of the case studies of four teachers in her school. Two studies (Zhu and Ng, *ibid*) adopted content analysis as the main research method to examine all the problems and model solutions presented in school mathematics textbooks for evidence of Polya's problem-solving strategies.

Conclusion

This paper presented a review of only 101 postgraduate research reports from NIE, the only teacher education institution in Singapore. It could not however claim to be exhaustive nor representative of teacher research in mathematics education locally. Nevertheless, it was a snapshot from the teachers' perspective when they were given opportunity to do classroom research as a disciplined inquiry. The teacher researchers in this paper had taken advantage of the postgraduate courses to gain more current knowledge in mathematics education. They had applied and embarked on research constructing new knowledge as part of professional and self development. In addition to the day-to-day problems and issues of mathematics teaching and learning in the classroom, MOE's initiatives like "Teach Less, Learn More" (TSLN), "IT Masterplan", and "Assessment for Learning" could have driven many of the research interests in the present review. This systematic analysis of the studies had allowed the reviewer to identify some important variables in the domain of mathematics education research pursued through postgraduate theses and dissertations. So what could be learnt from this review of mathematics education research of the Singapore teachers?

A snapshot from the analysis, depicted that it was the student who received the most research attention and that the secondary and primary level of schooling were the two most undertaken contexts for research. This was reflective of the enrolment of graduate students in the MEd programme where secondary teachers usually formed the largest cohort followed by primary teachers and then JC teachers. Problem solving was the most popular topic while educational issue of how learners learned captured the most attention of the teacher researchers. What instructional strategies teachers had developed and how technology was used in mathematics learning were gaining more importance in the classroom. Research style of the teacher researchers was predominantly the traditional task assessment for qualitative data collection usually from intact classes, while quantitative surveys of large sample size had not been utilised in the early 2000s.

What more could be done in the future? The quality of research reviewed was not an issue for discussion in this paper. However, the knowledge gleaned from this small study might help to shape and improve the contents of graduate courses at NIE towards research. Positively it was commendable that more and more school teachers were developing professionalism through being engaged in research, albeit in small scale. This could lead to positive direction that might influence the current teacher culture of isolation to more sharing by way of publication of research findings and solutions that are pertinent to effective practices of teachers. In the midst of all the so-called new curricula initiatives and as the research culture matures with more collaborations among teacher researchers and with university

researchers, it is hoped that there will be more critical questioning and thinking through new ways of doing research amongst teachers. This in turn would enhance creation of new ideas for improving teaching and learning mathematics in our classrooms.

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