
Title	Restructuring a mathematics methodology course
Author(s)	Lim Suat Khoh and Yap Sook Fwe
Source	Maths Education Lecturers' Association Conference, 3-4 July 1996, Melbourne, Australia

Copyright © 1996 The Authors

This document may be used for private study or research purpose only. This document or any part of it may not be duplicated and/or distributed without permission of the copyright owner.

The Singapore Copyright Act applies to the use of this document.

Citation: Lim, S. K., & Yap, S. F. (1996, July). *Restructuring a mathematics methodology course*. Paper presented at the Maths Education Lecturers' Association Conference, Melbourne, Australia.

This document was archived with permission from the copyright holders.

**RESTRUCTURING A MATHEMATICS
METHODOLOGY COURSE**

Lim Suat Khoh
&
Yap Sook Fwe

Paper presented at the Maths Education Lecturers' Association Conference
held in Melbourne, Australia, from 3-4 Jul 1996

RESTRUCTURING A MATHEMATICS METHODOLOGY COURSE

LIM SUAT KHOH & YAP SOOK FWE

NATIONAL INSTITUTE OF EDUCATION,
NANYANG TECHNOLOGICAL UNIVERSITY

The National Institute of Education is the sole institution for training teachers in Singapore. The Mathematics Methodology Course is one of the courses for the pre-service program Postgraduate Diploma in Education (Secondary) and is compulsory for potential secondary mathematics teachers. A major restructuring of the course was conceptualized and implemented for the 1993/94 academic year with aims of promoting greater student initiative and self-learning and of providing a higher degree of theory-practice linkage. This paper gives a report of the development, implementation and evaluation of the restructured course.

Introduction

In the Singapore school system, secondary school and junior college teachers are usually university graduates specializing in teaching one or two subjects. Up to 1995, for teaching of the main school subjects, potential teachers are drawn from graduates of the local National University of Singapore or a recognized foreign university. These are normally B.A. or B.Sc graduates who would have covered the relevant two subjects in their undergraduate course. They would then undergo a one-year Postgraduate Diploma in Education (PGDE) (Sec) Program at the National Institute of Education which is the sole teacher training institution in Singapore. Before entering the PGDE(Sec) program, these trainee teachers usually have little experience in classroom teaching except for some who have done relief (or temporary) teaching during university vacations. Within their effectively 9 months of training in the pre-service program, they are expected to attain proficiency and competency in general educational principles and skills of teaching.

As mathematics methodology lecturers, we were concerned with the quality and effectiveness of the our methodology course in preparing these trainee teachers for mathematics teaching. Over the past ten years, the emphasis of the course has gradually shifted from a theoretical approach that focused on broad pedagogical principles to a more practical approach where teaching ideas and approaches for specific topics are dealt with in conjunction with the underlying principles and theories. This paper gives an account of a restructuring of the course for the 1993/94 academic year which involved much greater student participation and responsibility.

The PGDE(Sec) Program and the Mathematics Methodology Course

The PGDE(Sec) Program consists of general education courses covering the local system, general educational principles, psychology, technology etc. which are common to the cohort as a whole as well as specialised courses in the two teaching subjects. Trainees whose main teaching subject is mathematics would be mathematics majors while those for whom mathematics is their second subject have first teaching subjects ranging from Physics, Chemistry and Biology to English language, Geography, History, Economics, Physical Education and Music. However, the latter would generally have read at least first year university level mathematics. The mathematics methodology course is a 90 hour course preparing both these groups trainee teachers to teach mathematics. Though not part of the methodology course, trainee teachers whose main subject is mathematics will be supervised during the 10-week practicum period by Mathematics Division staff.

Prior to the restructuring, the components of the course were (a) 10 hours of mass lectures on the Singapore mathematics curriculum, learning theories, classroom organization for mathematics learning, technology in mathematics education (computers, calculators) (b) 60 hours of workshops (for groups of 25 to 32) on the teaching of various topics (Arithmetic, Algebra, Geometry, Calculus, Trigonometry, Probability and Statistics, etc.), hands-on practical sessions on problem-solving, investigations and on assessment in mathematics and (c) 30 hours of practice-teaching sessions for trainee teachers to carry out the teaching of segments of mathematics lessons.

Conceptual Framework

From observations in the course and of our trainee teachers' performance during the practicum as well as feedback from graduating trainees and trained teachers, we have evidence that the trainee teachers liked the practical orientation of the course and found the course useful and helpful in their preparation as mathematics teachers. Nevertheless, there were complaints that although the methodology lessons included discussions both as a class and in small groups, the level of interaction among the trainees was too low. Our trainee teachers felt that the relevance of education theory had not become apparent by the end of their initial training course. From observations and discussions during supervision of teaching practice, lecturers also felt that trainee teachers still had difficulty relating theory to practice.

Our reasons for restructuring the course stemmed from our basic concern that the existing approach was not effective enough in providing the link between the theoretical and practical aspects of teaching mathematics. Trainee teachers should be given more opportunities to reflect about their experiences in learning, examine their own attitudes towards mathematics and their beliefs about what mathematics is and how it should be taught (Brown & Baird, 1993). In addition, we wanted the trainee teachers to interact and work together as much as possible so that there will be free flow and exchange of ideas and experiences.

Our plan for the course was conceptualized along the same sort of thinking that underpins cooperative learning. It is an approach that involves small groups of learners working together as teams to solve problems, complete tasks or accomplish set goals. It was felt that the approach would be effective for the following reasons:

Firstly, we wanted all the student teachers to be engaged in the learning process in one way or another by presenting their ideas, contributing to discussion or critically commenting on suggestions put forth by fellow students. We noted that students tended to remain rather passive during discussion sessions in lectures/workshops and hardly volunteered to express their views or comments. This is particularly true of student teachers who have been in the science stream and who are not used to critical appraisals, discussions, evaluating and presenting their own views. According to Brown & Atkins (1988), students at tertiary institutions were more motivated when they viewed success or failure as a function of their own effort. By allowing students a greater input in discussions, we felt that they would be more motivated to put in their best effort.

Secondly, we have found from past experiences that trainee teachers, especially from the sciences, do not have the habit of referring to library and other resource materials except when writing projects or doing presentations of journal articles. In order to encourage them to build up their resources, the tasks required student teachers to consult journals and other library references before they could conduct group discourse to complete the task.

Thirdly, our student teachers had not been exposed to the cooperative learning strategy when they were in schools. Actually involving them in cooperative learning would be a very direct way of giving them first-hand experience in seeing the method at work.

We had three goals for the restructured course: (1) to help students increase confidence in planning instruction by having a more holistic view of the lesson planning process; (2) to broaden their conceptual understanding in mathematics teaching and (3) to expose students to team work and professional sharing at the beginning of their teaching career.

Design and Implementation

We felt that exposure to the certain core factual theoretical topics of the course could be dealt with in the mass lecture class (of 310 students) with follow-up sessions in smaller classes of about 30 students during the lecture cum workshop sessions. We therefore retained the series of 10 lectures as described above. These lectures were shared out among the 5 lecturers in the team while each lecturer was wholly in charge of 2 workshop classes.

As before, discussions of teaching ideas and approaches for various topics were taken up during the lecture cum workshop session. Within each topic, the lecturers would, in the past, cover aspects such as difficult concepts, relevant research concerning errors and misconceptions, teaching approaches and classroom ideas, etc. In the restructured course, it was decided that, in 5 selected topics, the students would carry out a self-learning process along the lines of these same aspects: looking up appropriate references, discussing and comprehending the content as a small group and finally presenting such materials to the class.

Students in each workshop class would be divided into five working groups at the beginning of the course. For each of the five selected topics, namely, Algebra, Geometry, Trigonometry, Calculus and Statistics, the five working groups would be assigned, on a rotation basis, one of five tasks for discussion and presentation. The five tasks focused on different aspects of the teaching of a Mathematics topic. See Figure 1 for a general description of the tasks:

Figure 1: Description of Tasks

- Task 1: Examine the various concepts involved in the topic, draw concept maps, explain difficult concepts at the pupils' level.
- Task 2: Examine theories, approaches, common errors and misconceptions relevant to the topic and implications for teaching.
- Task 3: Suggest ways to motivate the topic using history, stories, real life applications, enrichment activities, teaching aids, etc.
- Task 4: Develop lesson plans for teaching some pre-specified concept/skill/procedure.
- Task 5: Summarize, critique and comment on the other four groups' presentation. Briefly review one additional article.

The design of the tasks together with the provision of appropriate references was a major task for the lecturers. This was done in the long vacation preceding the 1993/94 academic year which began in July 1993. The team of five lecturers of the course were all involved: first, each chose one of the five topics and prepared drafts of the tasks, accompanying guidelines, discussion questions and journal/library references. The tasks were drawn up based on the lecturers' expertise and knowledge of research literature as well as on teaching and supervision experiences in the Singapore School System. These drafts were then put together for discussion and critique, after which the tasks/references/guidelines were modified in order that the five sets were comparable in terms of effort required for the different tasks.

Presentations for the first 3 tasks were carried out during the first session for the topic and those for the last 2 tasks during the second session. In this way, development and critique of lesson plans could be made with reference to the ideas from the first session. Each group was allotted approximately half an hour for presentation. Group members would take turn to do the presentation. For the first four tasks, typically two to three persons would present each time. For the fifth task, all group members had to make comments/suggestions. Assessment of the presentations was done on a group basis so as to create positive interdependence among the members. Guidelines, discussion questions and journal/library references were provided but students were encouraged to read beyond the given references, reflect on past experiences in learning and/or relief teaching and think of creative ways of completing their tasks. By assigning tasks on a rotation basis, each group would experience each of the 5 aspects as typified by the 5 tasks for at least one topic.

The five topic presentations were rather evenly spread out over the first ten weeks of the course so that students would have enough time to meet and discuss outside curriculum time. To ease students into the various tasks, during the first week of the course, the lecturer of each class went through the topic Arithmetic along similar lines (of concepts, errors, motivation and enrichment, lesson planning) to explain and illustrate what each of the first four tasks entailed.

All other lecture/workshop sessions (on topics such as mensuration, functions and graphs, probability, vectors and matrices, etc) were led by the lecturer of the workshop class and would include expositions interspersed with discussions and contributions from the different working groups and very often with hands-on group investigative work. For these sessions, students were also provided with references for further reading.

Besides the mathematical topics, the workshop sessions also covered general areas such as problem solving, assessment in mathematics, investigations and project work. In

topics other than those for student presentation, the team of lecturers also prepared and shared materials (discussion questions, reading references, hands-on activity worksheets, etc) to be used although each lecturer was free to use the materials or not as he chose.

The modes of assessment for the course included an open-book test on lecture material, assessment of the group presentations as well as lesson presentations in which the trainee teachers simulated classroom teaching. There was also a school-based project which the trainee teachers had to plan, implement and report on when they completed their practicum.

Learning Outcomes

The learning outcomes of the restructured course were measured by classroom observations, informal interviews, performances at the test, practice teaching and teaching practice. Our students were generally very serious and enthusiastic about the topic presentations. They reported having intellectual and stimulating discussions in relation to the tasks about their own perception of the nature of mathematics, what learning mathematics is about, how they have learnt mathematics over the years and how to teach mathematics in an interesting way. In particular, many students realized that they have been taught mathematics in a rather instrumental manner (Skemp, 1976) and were excited to find that many strategies and approaches exist to teach mathematics meaningfully. There was some apparent change in the thinking of some students who previously believed that mathematics teaching is nothing more than the mastery of factual knowledge and acquisition of algorithms and skills in solving problems.

Many of our students admitted that after leaving the school for years, they had not kept up with the changes in the school syllabus. The task of drawing concept maps forced them to go through the main concepts for a topic over the different levels to forge the links among them. Through reading about research studies and sharing with fellow students who have done relief teaching and/or tuition, they were also made aware of errors and misconceptions in learning the different topics. Such awareness is valuable and important information in helping them plan future lessons.

Traditionally, history of mathematics is not taught in the Singapore schools and the local National University of Singapore. The inclusion of historical topics in the motivation task served a twofold purpose of introducing our students to mathematical history and letting them recognize its value in the teaching of mathematics. Our students were amazed to learn about how mathematicians "invented" or "discovered" some of the well known mathematical results that they have taken for granted. In particular, our

Chinese students were surprised to learn that Chinese mathematicians made many important contributions (e.g. Pythagoras' Theorem, Pascal's triangle, the value of pi) long before their western counterparts.

Many students told us that they particularly intrigued by the range of teaching aids available for teaching the various topics. In one class, students went beyond the requirement of the assigned task to design an interesting game for learning algebra. In the past, we had also demonstrated the use of teaching aids in the methodology classes, but only a few students actually exhibited this degree of enthusiasm and not too many would actually use these ideas for their teaching in the schools.

The task of writing and presenting lesson plans provided excellent opportunities for lecturer and students to discuss how theory can be put in practice and how difficult subtopics could be approached. For example, in teaching simultaneous equations, the traditional approach used in the classrooms is to teach the skills of solving via elimination and substitution and then apply the skills to word problems. One of the subtasks in lesson planning for algebra involved developing a lesson plan for teaching algebra word problems involving simultaneous equations, taking into consideration the research findings about pupils' difficulty in translating the word problem into algebraic symbols and equations (Schoen, 1988). Based on the examples designed by students, we discussed the importance of problem solving heuristics and language issues in solving word problems. We also considered the possible merits and demerits of the alternative approach of using such problems for introducing the topic.

The task of summary and critique was helpful in building students' skills in critically evaluating the feasibility and effectiveness of teaching ideas. Their presentation skills improved rather noticeably over the training period. They learned to be more selective and more organized in their presentation, using more visual representations and more varied modes of presentation such as role play and dialogue.

Later in the course, we also found that these presentation tasks were helpful in preparing students for their practice teaching sessions. There were conscious attempts to apply some of the theories in their teaching, for example the use of standard and non-standard orientations in teaching geometrical concepts as implied by the Van Hiele theory. Although the practice teaching sessions lacked the authenticity of real classroom setting, they provided teachers with no prior teaching experience a taste of what lesson preparation and lesson presentations were about. We were happy to see that besides the growth in content knowledge and pedagogical skills, some of our students also become more resourceful. They took the initiative to build up their own resource files by sharing course materials developed, searching library references and video materials.

Conclusion

Examining the re-structuring in the light of its intended objectives, there was definitely a higher level of participation and interaction amongst students in the realm of mathematical communication. Lecturers were not deemed as the main source of pedagogical knowledge. Students learnt to evaluate proposed ideas in teaching and there was more sharing and cooperation among the student teachers. Students were more convinced about the benefits of cooperative learning and there was also evidence of the development of a cooperative learning spirit which is all too rare in competitive Singapore where meritocracy is the watchword for all sectors from business to education.

However, although students enjoyed the topic presentations, they found the preparation work very demanding especially taken with the assignments from other courses. There were many requests for a reduction in the number of tasks to be performed so that students could do a really good job. Besides, in providing more time for class participation and presentations, there was not enough time for the lecturer to comment and make suggestions. In particular, certain aspects of teaching such as questioning techniques, use of worksheets and error analysis were not adequately emphasized. This suggested an increase in the ratio of teacher exposition time to student presentation time.

The course restructuring was both an experience for our students as well as for us, the lecturers. The nature of the restructured course required a great deal of cooperation and coordination among the lecturers. Expertise and experience were shared and differing opinions were sorted out so as to make the new structure work. In effect, there was less flexibility exercised by the individual lecturer but the course became more unified and organized. The restructuring turned out to be a learning process, a means of self-renewal through which we become reflective practitioners along with our preservice teachers.

References

- Brown, G. & Atkins, M. (1988), Effective Teaching in Higher Education, Methuen.
- Brown, C. A. and Baird, J. (1993), Inside the Teacher: Knowledge, Beliefs and Attitudes. In P. S. Wilson (Ed.), Research Ideas for the Classroom: High School Mathematics, p.245--259. New York, NY: National Council of Teachers of Mathematics.
- Schoen, H.L. (1988), From Words to Algebra: Mending Misconceptions. In Coxford, A. F.(Ed.), The Ideas of Algebra, K-12, (1988 Yearbook), p.119-126. Reston, VA: National Council of Teachers of Mathematics.
- Skemp, R. (1976), Relational Understanding and Instrumental Understanding, Mathematics Teaching, 77, p.20--26.}