

Critical Moments in a Teacher's Attempts to Introduce Discussion-Based Teaching into a Secondary Mathematics Programme

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The purpose of the project is to document the progress, over one school year, of a mathematics teacher in a secondary school in Hong Kong, as he attempts to enhance mathematics learning through the introduction of a discussion-based approach. The results of the study will give insights into the kinds of difficulties experienced by a teacher trying to implement a non-traditional teaching approach, as well as giving some understanding of the role of discussion in a Hong Kong mathematics classroom. This paper presents a progress report of the teacher's feelings about the innovation after the first five months of its implementation, and the factors affecting these feelings.

Introduction

With recent reforms in mathematics education (NCTM, 1989; Australian Education Council, 1991; Curriculum Development Council, 1994), mathematics teachers in many countries are faced with the dilemma of whether to, and how to, change their teaching approaches. Despite sound research evidence supporting these recent innovations, "it is sobering to note that the history of reform in mathematics education is largely one of failure" (Gregg, 1995, p.444). A pattern of teachers reverting to traditional practices has persisted even if they are initially enthusiastic about implementing a new approach (Gregg, 1995). Consequently, it is important to gain insight into the factors which can influence teachers' decisions to adopt, or not to adopt, changes to their teaching. Simon (1993) suggested that an understanding of factors which can contribute to, or inhibit, successful change can best be achieved by "careful study of teachers as they transform their practice and of their developing conceptions" (p.107).

The dilemma faced by a young teacher in Hong Kong is perhaps even greater than in most western countries. On one hand, curriculum documents are recommending that teachers "ask more open-ended questions... and in general play the role of facilitator, so that students must do the thinking and justify their conclusions (Curriculum Development Council, 1993a, pp.26-27), and "involve students actively in their learning process, to train them to organize ideas and information, and to develop the skill of discrimination and judgement...interact with each other [and]... exchange views and form tentative conclusions" (Curriculum Development Council, 1993b, pp.48). On the other hand, the standard of examination performance is exceptionally high in Hong Kong and teachers are faced with pressures from senior colleagues, parents, and students to cover the syllabus and prepare the students to succeed in knowledge-based examinations. Many secondary mathematics teachers believe there is little place to implement reforms, because there is so little time available to spend on any one topic. Furthermore, there is a very strong cultural belief in the role of the teacher as conveyor of knowledge and the pupils as recipients, which is very much conducive to traditional approaches to teaching (Leung, 1995).

To enable them to resolve this dilemma, it is important for teachers to explore ways of finding a balance between the traditional approach which has achieved good results for generations of Hong Kong students, and newer strategies which curriculum reformers are suggesting can enhance these results, and make mathematics more accessible to a wider range of people (NCTM, 1989). Hence, this project focuses on one teacher as he attempts to address these conflicting issues and explore how and when new approaches can enhance the quality of the mathematics learning in his classroom.

The issues which can influence the successful implementation of change are complex, and raise questions about the strategies the teacher needs to use to encourage maximum student participation, the respective roles of the teacher and the pupils, and the extent and nature of changes in these over time, the contribution of the reform to the

students' understanding of mathematics topics and their ability to transfer knowledge to unfamiliar contexts, and the teacher's and the students' beliefs about the value of the reform. The purpose of this paper is to address one aspect of the project, that is the changes in the teacher's feelings about the innovation, and to try to identify the critical moments and major factors which can influence these feelings.

The particular mathematics reform which has been chosen for examination in this project is that of co-operative discussion. The rationale for this is based on theories which advocate the use of discussion in helping learners to build up conceptual understanding of mathematics and become mathematically literate (for example, Schoenfeld, 1985, 1987; NCTM, 1989; Von Glaserfeld, 1991). It is linked to the social constructivist notion that people learn most effectively by constructing knowledge in social settings (Vygotsky, 1962). The use of discussion is fundamental to this notion (National Research Council, 1989), and there is research evidence (for example, NCTM, 1989; Webb, 1991; Cobb, Wood and Yackel, 1993; Hart, 1993) which suggests that the appropriate use of discussion improves students' mathematical achievement. Yackel, Cobb and Wood (1993), for example, believe that "collaborative discourse can help children clarify their own understandings by talking...and by reconceptualising their own cognitive structures as they attempt to make sense of their partner's explanations" (p.35). Not only can it enhance learning, discourse can also be useful in enabling the teacher to gain insights into whether the students have inaccurate or incorrect understanding (Wood, Cobb and Yackel, 1993). Models for classroom interactions have been proposed which include whole-class discussion, co-operative grouping, and pair problem solving (Cobb, Wood and Yackel, 1993). The teacher's role is critical as catalyst and coach, in designing tasks and asking appropriate questions to guide the students' understanding (NCTM, 1989).

Methodology

A case study methodology is being used for this project for the purpose of portraying "an educational problem in all its personal and social complexity (Stake, 1988, p.254). Accounts are being collected from the points of view of three stakeholders: the teacher, the student groups, and a group of observers who include the teacher's colleagues and the researcher.

The teacher in the case study is a full-time third-year teacher who is enrolled in a part-time Postgraduate Certificate of Education course. He has a background in philosophy and psychology, and spent a year tutoring in a university philosophy department before commencing his career as a secondary mathematics teacher. This experience had shaped his philosophy about how he thought mathematics should be taught and, following exposure in the course to issues concerning social interaction and discussion in the mathematics classroom, he expressed a belief in the value of this kind of approach and an interest in incorporating it into his teaching.

The classes which the teacher is using the discussion approach are two Form 4 classes in a Band 5 school. Form 4 is the fourth year of secondary schooling, and Band 5 is the lowest level in the selective secondary system. One class is in the Science strand and the other the Arts strand, but both groups have below-average mathematics skills, poor motivation, and fluctuating behavioural problems.

Data are being collected over the period of the 1995/96 school year, to explore the nature and extent of change as the teacher learns more about the use of discussion, and the students become more accustomed to the approach. Data sources include the teacher's lesson plans and evaluations, written and tape-recorded samples of students' work, written and tape-recorded reflections from the students, observations by the researcher, and monthly interviews with the teacher.

Results

Background and Description of the Activities

During the first two months of the teaching experiment, there were two main topics taught: graph plotting and quadratic equations. Typically, between twenty and thirty minutes of each forty minute lesson were spent in discussion, which involved students working in pairs or groups of four to solve tasks posed by the teacher, then presenting their solutions for class discussion. During the third and fourth months, the teacher found it necessary to reduce the amount of time spent in discussion and return to a more teacher-delivery oriented approach, due to the need to rush through two chapters to complete work in time for examination revision. The topics covered during this time were polynomials, remainder theorem, factorisation theorem, indices, logarithms and sets. While the main mode of delivery was traditional, the teacher conducted three major discussion-based lessons and several shorter discussions of about ten minutes with each of the two classes. As well as setting some specific questions for discussion, the teacher would often ask the students to work in groups to find solutions to the text-book examples set as class exercises.

The fifth month was spent in revision of examination topics, and in the introduction of one new chapter, on ratio, proportion and variation. During the revision time, the teacher introduced the idea of giving the students solutions which he had prepared to old exam questions, and asking them to evaluate these and locate errors. This approach was used at least twice a week. The students would work in small groups, then participate in a teacher-led discussion at the end of the lesson. During the introduction of the new chapter he continued with the approach of presenting a question and conducting whole class, large group and small group discussions of the solutions. During the fifth month, he also commenced an extra curricula discussion/revision group which met twice a week and was attended by an average of six volunteer students.

Changes in the Teacher's Feelings

By the end of the second month, the teacher felt that some small progress had been made, and that it was worthwhile to persist with the discussion-oriented teaching approach. By the end of the fourth month, however, he had mixed feelings about whether or not to continue with the experiment. While he still had a fundamental belief in the value of discussion to enhance learning, he was beginning to feel that the experiment was being made increasingly difficult by the combination of a number of factors. This suggests that he may have reached a critical stage, where it would be very easy for him to abandon the reform. One month later, he felt that a corner had been turned, and that the experiment was at last beginning to succeed. He estimated then that 70 per cent of the Science class and 40 per cent of the Arts class were participating actively in discussions.

Because the teacher came so close to abandoning the reform after four months, it is important to examine the factors which were predominant at this time, and those which influenced his change of feelings a month later. These factors will be examined from the points of view of the different stakeholders.

Contributing Factors

Students' Attitudes and Beliefs: One group of factors exerting considerable influence on the teacher's feelings, were the students' attitudes and beliefs about the discussion approach. Simon (1993) has suggested that students who have long-established traditions of being told "how to do it" resist an approach which encourages them to take responsibility for their own mathematical thinking and decision-making, and this was certainly the case in this study.

During the first two months, both the teacher and an observer noted that most students in the class lacked confidence, willingness, and ability to discuss or to share ideas, and most of the students were not doing anything at all to contribute to the group's solution. The observer's comment was that "only a few students were involved with learning". Some students were prepared to give answers, but had no self-confidence and

were neither prepared, nor able, to defend their points of view. In interview, the students indicated that when the teacher asked for clarification with a question like, "How do you know that?", they felt that he was criticising them.

Most students just watched or copied what their more active peers were doing, and made no attempt to understand. The teacher also believed that they were sometimes just lazy, knowing how to do it, but finding it easier to let someone else do it for them.

After two months, the teacher conducted an interview with ten students, and their comments confirmed many of his suspicions. The students in the Science strand did not react favourably to the expectation that they participate in discussion. They did not either understand or accept the approach he was using, and lacked confidence in his new approach. They firmly believed that the teachers should convey knowledge, and that getting them to talk was not worthwhile. The majority preferred to learn passively, and thought that it was a waste of time to include discussion. Furthermore, they wanted the lesson to be oriented towards their examination, and the teacher had not yet introduced any examination questions. They were not interested in the teacher's explanation, that he needed to develop their foundation knowledge before they could move towards the examination content. During the third and fourth months, the teacher still expressed concern about the general lack of willingness to participate.

After four months, sixteen students completed a questionnaire and open-ended written responses regarding their attitudes and beliefs about the innovation, which suggest a slightly more favourable attitude than two months earlier. Those who responded to the questionnaire were evenly distributed in their acceptance of the discussion approach. They were divided as to whether or not they would like to use the approach again in the new semester. They seemed to think that the use of discussion helped their understanding at least to some extent, although their preference depended on other factors, such as the topic, and their store of background knowledge to draw on to answer the questions. The students felt that the new approach had helped them with at least some of their examination preparation. While they were evenly spread in their opinions as to whether the use of discussion aroused their interest in mathematics, they did indicate that it made them more attentive, and also that it helped them to remember the concepts better. Some students said that they found great difficulty with presenting points or developing discussion, with the consequence that there was either no discussion at all, or that it ended quickly and students daydreamed or did other things. The three brightest students in the Science class were particularly enthusiastic about the value in the innovative approach, and formed their own study group to continue their discussions after class.

By the end of the fifth month, the teacher had observed substantial changes in the students' attitudes towards participating in discussion, particularly in the Science class. He attributed this, at least partly, to the fact that, after a discussion with the class about the importance of their feedback, the students had responded well to the opportunity to be partners in the decision-making. At their request, he made the questions more exam-oriented and they responded well to this. Even some of the badly behaved students wanted to share discussion with their classmates. Students who were previously unwilling to ask questions in their small groups were prepared to ask their group mates for explanations when they did not understand. Whereas, previously, they had felt threatened by the question, "How do you know that?", they were now willing to defend their thinking.

Students' Knowledge: After the first two months of using discussion, the teacher believed that some of the responses of about one quarter to one-third of the class indicated that the discussion activities had contributed to the students' knowledge and understanding of the topic. Nevertheless, one of the major problems the teacher observed was that the majority of students lacked the conceptual background which would enable them to participate in discussions successfully. An observer noted, in the second month, that only one group had the necessary knowledge to be able to complete the discussion task successfully. This problem had become particularly evident with the Arts group by the end of the fourth month. Questions which required proof statements and use of the strategy of finding contradictions were not answered well. The students were interested

at the start, but lost interest when they found that they did not have the knowledge base to be able to answer the question. The teacher suspected, and the students confirmed in interview, that they often found it difficult to construct their own knowledge easily from the class activities, because they could see little linkage. Despite the fact that the teacher tried to make the activities exam-oriented, the students still thought that there were gaps between these activities and their need to get good exam results. There seemed to be a link between the students' knowledge and the extent to which they were prepared to participate. It was recorded by the teacher, and by the students, that if they felt confident that the activity was within their capabilities, about one half of the class would work actively on the task.

A further problem which the teacher identified was that the students did not have very good explanation skills when presenting their groups' findings to the rest of the class. Often, they would just write the main points on the blackboard, with no elaboration of what they were doing.

After five months, the teacher was beginning to feel that the tasks he was setting were more consistent with the students' knowledge and experience. He thought that the strategy of giving them pre-prepared solutions to evaluate had an unexpectedly good effect because it gave them some background support instead of expecting them to start from their own knowledge. The students reported that they also felt more comfortable with this approach, because they felt previously that he had been scolding them for their lack of knowledge. The teacher found that, as the students became more confident, they also became better at constructing their own mathematical thinking, and the brighter students actually gave some insightful responses which could then be used as a basis for further discussion.

Management: After two months, and again after four, the teacher described several management issues which he had been addressing systematically, but did not feel that he had fully resolved yet. One was that teacher supervision could not run smoothly, because there were too many groups for the teacher to take care of. The students and an observer also indicated their concern that the teacher could only take good care of one group at a time. Because the teacher could not be present at all groups, some students thought that they were being neglected. The observer commented specifically on the students' lack of self-discipline.

Another of the management issues which the teacher faced was that there was not a sufficiently large distribution of high ability students, capable of taking leadership roles in the discussion, to allow for every group to have an effective leader. Furthermore, he observed that the students did not have a very high level of self-control to be able to engage in group discussions, and that it was difficult for him to maintain control of all of the groups. The teacher was observed during January by the vice-principal of the school. His particular concerns were that the class order was sometimes not good and that the noise level was sometimes unacceptably high.

After five months, the teacher reported that he had negotiated some classroom management issues with the students, with favourable outcomes. At the students' request, he had taken disciplinary measures with some who were not behaving in class activities, with the result that the previous non-participants had begun to take his expectations more seriously. He also experimented, successfully, with having a smaller number of groups for some sessions, which made the students feel that he was sharing his attention more evenly.

School Policy: During the January interview, the teacher expressed his concern that he did not want to conflict with school policy in his attempts to change his teaching approach. He had received some advice, particularly from the vice-principal, that what he was doing was inconsistent with the school policy of a silent classroom, with just one voice from the teacher. The vice-principal also suggested that it was contradicting school policy to include too many class activities, which might have prevented him from completing the required work in time. This mis-match between the school philosophy and his own was a critical factor which could easily have influenced him to abandon the project.

Support from Colleagues: After two months, the teacher was sufficiently enthusiastic and confident about the project to work independently. However, two months later, he was feeling the need to engage in professional dialogue with his colleagues about what he was doing, and was discouraged by their lack of willingness to respond to his need. While the researcher and his classmates were available to give support, it was the collegial support within his own department which was most important to him and which was not forthcoming. This need for emotional support is one of the necessary components described by Weisglass (1994).

At the end of the fifth month, the teacher reported that he had been sharing some of the students' insights with his colleagues, with the result that they were beginning to show an interest in the students' thinking. He was beginning to feel that this was opening discussion channels, and that he was less isolated from his colleagues than he had felt himself to be earlier.

Syllabus Constraints: Gregg (1995) mentioned the impact of syllabus constraints on mathematics teaching: "the text will continue to be viewed as a mathematical authority, and the teacher's role will continue to be that of covering the formalized mathematics presented in the textbook" (p.464). The fact that the teacher had to modify his approach to cover the syllabus content in time for the examinations indicates that this was a major factor influencing his feelings about the project. Furthermore, students' comments suggested that one of their objections to using the new approach was that they were afraid the syllabus would not be completed in time, and the vice-principal expressed the same concern. At the end of five months, the same syllabus and time constraints applied as previously. However, both the teacher and the students indicated that they were happier with the discussion topics being more directly related to exam questions.

Discussion

It must be emphasised that this paper presents a half-way report of research in progress. Nevertheless, some interesting, if predictable, changes have occurred in the teacher's feelings about the innovation. He has gone through four stages in the first five months of implementing the new approach. The first stage was one of *enthusiasm and confidence*. He believed in the value of the approach, had a sound theoretical knowledge of the principles, and was confident that the teaching experiment would succeed. The next phase was still one of *hopefulness*, that the obstacles would be overcome. Four months into the experiment, he was expressing *mixed feelings* about whether to continue. This, then, was a critical time, when it would have been very easy for him to abandon the project. Given the interaction of the many factors discussed above, it is not surprising that his feelings were mixed. A slight shift in the students' attitudes and beliefs, from hostile to ambivalent, was not enough to over-ride the other factors. The most critical factors in influencing the teacher's negative feelings at the time when he was most ready to give up were difficulties in: gaining the students confidence in the value of what he was trying to do; identifying appropriate tasks which would cater for the students' level of knowledge and experience; developing classroom management strategies appropriate for the new teaching approach; and having access to collegial support and professional discussion. The teacher believed that the factor which contributed most significantly to the fourth stage, *renewed enthusiasm*, after five months was that he had finally achieved the co-operation of the students in negotiating the activities with him. This, combined with the fact that he had found suitable discussion tasks to account for their restricted background knowledge, seemed also to lead to positive changes in the other factors which had contributed to his earlier negative feelings.

In the first five months of the project, there has been one "critical moment" where the teacher has come close to abandoning the new approach, followed by renewed enthusiasm. It is anticipated that, in the remaining five months of the project, there will be more highs and lows. Understanding the factors which contributed to this critical moment has given some useful insights which may help the teacher to cope with future

fluctuations in his feelings and which may also be useful to share with other mathematics teachers going through the process of reform.

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