

CHANGING MATHEMATICS TEACHING: THE CASE OF CHRISTINE BROWN

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In this paper, we describe the case of a teacher, Christine Brown, as she incorporates new teaching approaches and organisational strategies within her classroom practice. Drawing on a set of interviews and observations, we analyse the effects of the experimentations with classroom organisation, management and teaching approaches carried out by Christine. We find that Christine made significant shifts in her practice that are consistent with constructivism. Furthermore, her classroom experimentations did result in a change of beliefs about how students might best learn mathematics.

Concerns in New Zealand about student achievement in mathematics have led to the preparation of a substantial mathematics curriculum statement, 'Mathematics in the New Zealand Curriculum' (Ministry of Education, 1992). The statement recommends teaching approaches which are consistent with constructivism. There is also recognition that, in order to implement this curriculum initiative, significant changes in classroom practices will be required among a large sector of the mathematics teaching community.

Claxton and Carr (1992) have conceptualised the process of teacher change as passing through a number of stages. They suggest that change may involve teachers moving from initial rejection of an alternative approach, to consideration of the ideas associated with the approach, a phase of experimentation and evaluation of the results of the approach (sometimes associated with feelings of disappointment that it has not worked as well as it might), and finally a phase in which the approach is owned and incorporated in their teaching repertoire.

THE CASE STUDY

Christine Brown is one of eighteen teachers who participated in a Teacher Development Project. The teachers set their own goals and were asked to reflect regularly on the success or otherwise of their day-to-day classroom practice. They were encouraged by each other and by the Project researchers to make adjustments to their classroom organisation, management, and teaching approaches as they saw fit. The teachers participated in regular sessions where they shared teaching ideas, approaches and strategies.

Christine had been teaching at a girls' secondary school for six years. She indicated that, although she was a mature teacher, she was, 'not that experienced'. She expressed the belief that students need to understand what they're doing and why they're doing it and said that she wanted her students to develop an attitude of enquiry.

Christine was observed in her classroom on five separate occasions. Three of the observed lessons are described and analysed in order that shifts in teaching practices can be documented.

Lesson One (February 1991): Teaching Geometry: Angle Sum of Polygons

Students sat in rows facing the front of the class. In this lesson, students were first required to draw a pentagon, measure each angle and then add up the five angles after first estimating the sum. They were asked to record their results in a table format given to them by Christine. When the students had finished, Christine called for answers from every student in turn, recording them without comment on the board as she went. When all the angle sums had been recorded, Christine suggested that, "A lot are close and a few might want to add their angle measures again". She went on to indicate whose results should be reconsidered. Other students were asked to repeat the exercise with a quadrilateral and then go on to complete the table for other polygons given on a worksheet. She pointed out that, "Triangles should be close to 180" before asking the class, "What do you think a quadrilateral should be?"

A review of this lesson suggests that the task set for the students is 'closed' rather than 'open' and for the most part, students were required to 'discover' what mathematical ideas the teacher 'had in mind'. It was Christine who drew each of the tables for recording data. It is questionable whether the students realised that the process of tabulating data provided a helpful way to later view the data in order that generalisations could be made with some

ease. A constructivist teacher might have been more inclined to facilitate group discussions about good ways to present data so giving rise to a learning opportunity in which the useful strategy of tabulating data as an aid to pattern seeking might 'emerge'.

The evidence collected from these first observations suggests that Christine's learning model might best be represented as 'guided discovery' which, as suggested by Burkhardt and Fraser (1992, p 5), is 'really an alternative style of explanation'.

Future Directions

Christine used summaries of the observed lessons to help identify aspects of her teaching that she intended focussing attention on in the coming months. She subsequently set herself the goals of 'standing away from the board', encouraging students to take more responsibility for their own learning, extending her use of group work and using a mixture of teacher problems and student generated problems. In talking about 'standing away from the board', Christine indicated her intention for her lessons to become less teacher-centred and more student-centred. She explained her rationale for introducing group teaching.

... originally I used to have my class in single rows, and it was silly because ... and there were fifteen hands going up around the room. I've certainly used that quite a bit - you know - group setting. Single desks would be all right sometimes ... (Interview, May 1992)

Extracts from Christine's diary suggested that, while she plans for her teaching in the form of a simple yet structured agenda, she begins to comment on her role as a listener and observer during group activities, suggesting progress towards a more student-centred approach. While she identified student 'errors' that may have arisen from serious student misconceptions, she made no comment as to what she did about them at the time nor what strategies she might employ for overcoming them.

Lesson Two (April 1992): Teaching Equations and Graphs

Students sat in groups of four or five. The focus for the lesson arose out of a discussion between Christine and the researcher. Christine had been working on the beginnings of equations and the researcher suggested that this might be extended by looking at a graphical solution of pairs of simple simultaneous equations that involved a context familiar to the students. Making choices as to the best rate for babysitting among several such rates for different hours worked arose in the discussion so it was agreed that Christine would develop a lesson around this theme.

Christine presented the problem of choosing from three different babysitting rates: Smiths, who pay \$10 basic and \$2 per hour, Grants who pay \$5 per hour, and Thompsons who pay \$10 for up to 2 hours and \$4 per hour after that. Each group was provided with sets of tables showing time and earnings for the students to complete, an incomplete literal rule for each rate, and a graph of the Smith's rate as an example. Graphs illustrating the other rates were to be drawn on the same set of axes.

The students worked collaboratively on this problem for 40 minutes while Christine travelled around the room checking the progress of individuals and groups. The students then went on to make up and graph their own suggestions for babysitting rates.

As part of her lesson wrap-up, Christine asked the students to arrange their equations in order of steepness and then relate steepness to pay rate. In a brief class discussion that followed, Christine drew attention to the comparative steepness of two graphs that had been drawn on the board by students.

Following the lesson, Christine indicated that she felt that the lesson had gone reasonably successfully. "I usually start graphs by plotting points - '4 up and 3 across'. Today's lesson seemed to be much more successful because it built on what they already knew. They didn't seem to have a problem at all. Plotting points the way I have done it in the past is kind of sterile - it isn't related to anything." In a conversation with the researcher, a group of students indicated that they enjoyed maths like this, "because it is more than using numbers and multiplying". They also reported that for them, the mathematics involved in this problem was, "Making a choice - solving a problem". In subsequent written reflections on the lesson, Christine noted that the students really liked making up their own problems but reported that she found it difficult to draw the threads together in her wrap-up. She would have liked to have used more of their own examples but just ran out of time.

The lesson reflects Christine's use of an inductive approach in which she tries to assist pattern seeking leading to generalising by firstly setting up tables of data for the students to work on. While the continued use of this

approach, identified in each of the lessons observed previously, may suggest that Christine had made little variation to her general teaching approach, there are features of this lesson that suggest both development and change. The lesson had provided an opportunity for Christine to experiment with adjustments to her teaching in two areas. Firstly the lesson had focussed on a context that provided a real link with the students' own lives. And secondly, the interest generated from this real context had resulted in meaningful student interaction and collaboration as they made their decisions about the best rate.

The following comments made by Christine about this lesson illustrate the early development of Christine as a constructivist teacher.

... so from the problem which was one that I think they all related to pretty well, they actually learned a lot of things and they could see the point of drawing a graph, so we didn't sort of go, I didn't go and say this is how you draw graphs, this is an x-axis, this is a y-axis, and you know this is how you plot these points. We actually approached it from a place where drawing a graph would help us solve a problem. (Interview, May 1992)

Lesson Three (May, 1992): Teaching an Investigation Related to Volume

The main part of the lesson began with Christine relating a story to the class about a former colleague who embarked on a fund raising exercise at another school. The teacher, together with the school rugby team, had won a contract to deliver new telephone books throughout Auckland. But they had not worked out the amount of storage required for the books prior to delivery and were subsequently embarrassed as they began storing the books in every possible location at the school; the hall, the gymnasium and so on. Christine then went on to tell the class that she wanted them to see if they could find out how much room they would need; how many rooms (classrooms) etc, to store the Auckland phone books. Each student was then provided with a prepared handout with the following directions as to how to proceed.

- 1 Find out approximately how many numbers are listed in the book.
You will need to find out
 - how many pages in the book
 - how many columns in a page
 - how many numbers in a column
- 2 Work out how many phone books would fit into this classroom?
You will need to:
 - measure a phone book
 - measure the floor of this room
 - work out how many phone books would be needed to cover the floor
 - measure the height of this room
 - work out how many layers of books would fit
- 3 How many classrooms would be needed to store all the phone books?

Christine told the class that ... "at the end of the session everyone should have written down in their book all the important pieces of working". Christine then travelled around the class taking time to interact with each group. This involved, posing problems to focus students' ideas, explaining how to use equipment such as measuring tapes, explaining the steps the students should take, and asking students to explain their thinking and ideas. The following recorded interactions between Christine and a group of four students is illustrative of the teacher student interactions during this part of the lesson.

Christine: The next thing you need to do is to work out how many phone books would be needed to cover the floor. OK imagine how many phone books are going to fit all the way across the room like that? Can you work that out?

Students: Can we put the phone books on the floor?

Christine: Well you could but you should be able to work it out from what you've measured. You should be able to work it out from the measurements that you have written down. Now think about it.

Students: Shall we do it this way?

Christine: Right, how wide is that? You've got it written down.

Students: 21

Christine: Alright. So how many 21's are going to fit across here? How wide is this? Should we change that into centimetres. What would that be in centimetres?

Students: 7,300.

Christine: No, that's 735. Alright, so what you've got to do now is figure out how many times 21 goes into 735. Go to it. And you can write that down and then you'll have to do the same thing the other way but remember the book goes this way.

Christine began her lesson wrap-up by asking each group for their response to the question, 'How many phone books fit into this room?' The responses from three groups were similar and around 70,000 while the other two groups significantly different. One of these reported about 100,000 while the fifth suggested 780,000. Christine suggested that the last group had got an extra zero and then went on to suggest that they take the number of phone books in a room to be about 70,000.

A similar whole class discussion ensued about the number of phone numbers in a book. Christine concluded from the group responses that a reasonable assessment might be about 400,000 and then went on to explain that the answer they were looking for, that is the number of rooms required to store all the phone books could be found by dividing 400,000 by 70,000. Christine explained that a quick way to do this was to cut out some zeroes leaving 40 divided by 7 so producing an answer of about six rooms. Finally, she explained that each person listed in the phone book would receive three books (one book of white pages and two of yellow pages). So altogether 6×3 or 18 rooms would be required to store the books prior to delivery.

The lesson was tape recorded and analysed minute by minute. An analysis of the lesson transcript reveals that, while Christine used a 'real' problem to focus the lesson, the lesson itself was dominated by Christine as she first set the scene, posed the problem, and then assisted students individually or in groups to follow the steps required to solve the problem. There was little opportunity for students to devise their own plans of action and to discuss those plans prior to making the necessary measurements and calculations. Of a 55 minute period, 34 minutes were taken up with organisation, posing the problem and explaining, while 21 minutes involved asking open questions and listening.

Christine had intended that her teaching during the lesson observed in May, 1992, (Lesson Three) would be largely 'hands off', that is, she would take on the role of facilitator rather than that of explainer. The task she set, that of finding the number of rooms to store a new edition of telephone books prior to delivery, had been carefully structured so as to, in Christine's view, enable the students to find a sensible answer to the problem by following a sequence of steps. As a result of the careful structuring, the task which was both interesting and challenging, seemed to degenerate into a set of teacher prepared exercises. It seemed that Christine, in her desire to keep a close control of the lesson and its direction, had provided the mechanism for the students to, in turn, control her. Their inertia as they sought to understand what was expected of them coupled with their uncertainty as to the requirements of each step, provided the impetus for Christine to give the individual attention that students so often expect of their teacher. Thus Christine found herself in the role of explainer, not just to one student or one group but rather to all groups and all students. The mismatch between what Christine had intended and what had actually occurred led to some personal frustration for Christine and it is likely that this frustration in turn led to her doubting the efficacy of this teaching approach. A factor here is the change required of students under the new curriculum. If their teachers continue to see them as receivers rather than constructors, it is likely that they will act that way, thus making the job of the beginning constructivist teacher more difficult.

TEACHER CHANGE - WHAT HAPPENED FOR CHRISTINE?

The stages associated with teacher change conceptualised by Claxton and Carr, (1992), seem to be clearly evident in the change in teaching approach that Christine adopted during the Project. Certainly Christine underwent a phase of experimentation and as she experimented, there were the feelings of disappointment that her approach had not worked out as it might have. Experimentation was evident in the last two lessons. Both lessons used a group format to promote more student-centred activity and both began with Christine setting the scene with a situation that related to the world of the students. Christine herself identified this aspect as her significant area of change.

... I've tried to get them more now to think about problems. Before I suppose I tended to teach by skill and then extend that into problems whereas I try now more to go the other way. To look at problems first and then ... into skills. (Interview, May 1992)

Although there were disappointments as she experimented, Christine was able to confidently explain newly acquired beliefs about how students best learn mathematics. Her excitement with the results of her 'babysitting rates' lesson, together with the clarity of the explanation of the approach she used as the basis for successful learning in mathematics, suggest strongly that not only did Christine participate in Claxton and Carr's experimentation phase but also began to reflect upon her teaching practice and clarify her own philosophy. This is consistent with the findings of Schon (1987), which suggest that clarification of the ideas and philosophy of a new practice occur after experimentation occurs and those of Ellerton, Clements and Skehan (1989), who found that teachers involved in an action research project became more conscious of what they did and as they became more confident, they developed as reflective practitioners.

Shortly after the end of her involvement in the Project, Christine was invited to make some additional reflective comments on her teaching. The comments illustrate some of the personal conflicts that confronted Christine as she sought to make adjustments in her teaching. Her comments also indicate how Christine has resolved some of the conflict.

I have changed in that I am prepared to try different things, to allow noise and group activities and discussion, but I am not prepared to throw away the syllabus and 'go with the flow'. I am not secure enough to throw away all my props. I get upset when the environment seems 'messy' to me and when I feel that I'm not in control.

I do think that my classes are happier and have a more positive attitude to maths though I'm not sure if they actually learn more. I mostly enjoy my teaching and like thinking up new ideas or adapting those I've got from courses or other teachers. I seem to need this stimulation. If I am bored, then my classes become bored too. I need to continue trying new and different things so that my enthusiasm is contagious.

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