5

Classroom Interaction: An in-depth analysis

Introduction

Chapter 4 examined the dominant pedagogical practices in the classrooms observed. This chapter explores the dynamics of interaction within those different practices, namely the patterns of engagement between teachers and students and the nature of questioning and instructing. All public interactions are analysed along two dimensions, in terms of who initiated them and their specific character. As the unit of analysis was the class and its processes, rather than the experience of individual students, the analysis focuses primarily on the public aspect of the lessons. In the context of teacher-student initiated interactions, those directed to the whole class as well as to individual students were analysed. Public interactions directed by individual students to the teacher were also included in the analysis.

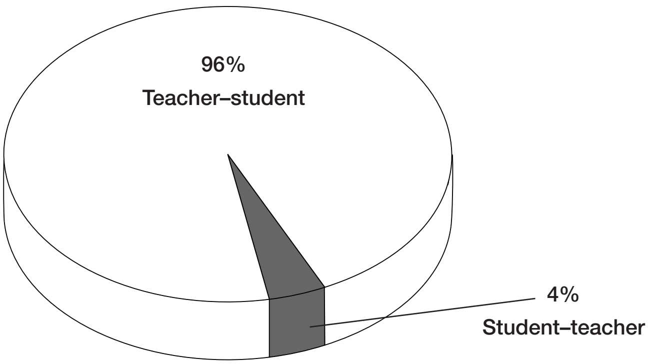
Not included in the analysis were private exchanges between the teacher and the students, or among the students themselves. While work-related interactions conducted privately between the teacher and the students occurred in seventeen out of the twenty lessons, they did not command much class time. Sometimes they involved merely a glance over a student's shoulder to check work, while in other cases it involved giving guidance on a specific task. Such interactions were generally initiated by the teacher and were of short duration. They occurred mostly during the student practice phases of the lesson, such as during the student work in class phase, or when homework was being corrected or partly undertaken in class.

One of the reasons for excluding these private exchanges from the analysis was the logistical impossibility of hearing and recording such interactions systematically on video. Most of the exchanges occurred when the teacher went to check or help an individual student, or (very infrequently) when students conferred with one another in quiet tones. Given the over-riding prevalence of public, teacher directed work in classes, and the lack of co-operative work between students, the exclusion of private exchanges also seems justified in research terms.

Patterns of public interaction

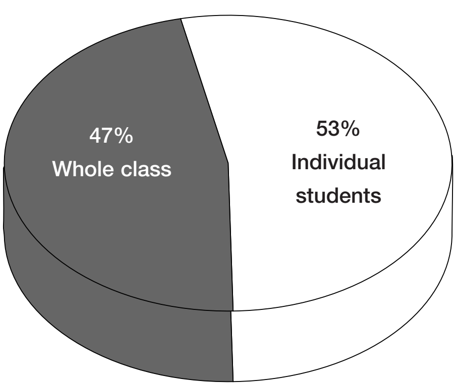
Overall, teacher initiated interactions comprised over ninety-six per cent of all interactions that took place over the twenty mathematics lessons. By contrast, student initiated interactions accounted for just less than four per cent of all interactions (Figure 5.1).

Figure 5.1: All public interactions: teacher–student initiated and student–teacher initiated interaction (n = 2980)



These teacher-student public interactions throughout the twenty mathematics lessons were fairly evenly distributed between those directed to the whole class and those addressed to individual students (Figure 5.2).

Figure 5.2: Distribution of teacher–student interactions (n = 2980)



In ten of the twenty mathematics lessons, between a quarter and a half of all teacher-student public interactions were directed to the whole class, while it exceeded 50 per cent in nine lessons (Figure 5.3). The use of whole class teaching contributes to a controlled environment that typifies the traditional view of mathematics.

Figure 5.3: Distribution of teacher–student public interactions by lesson (n = 20)

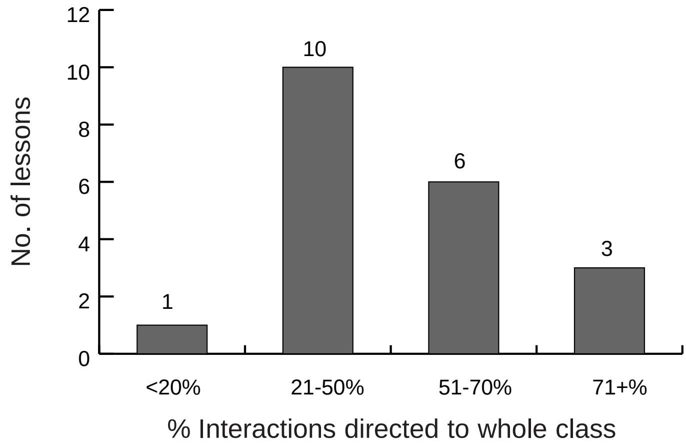
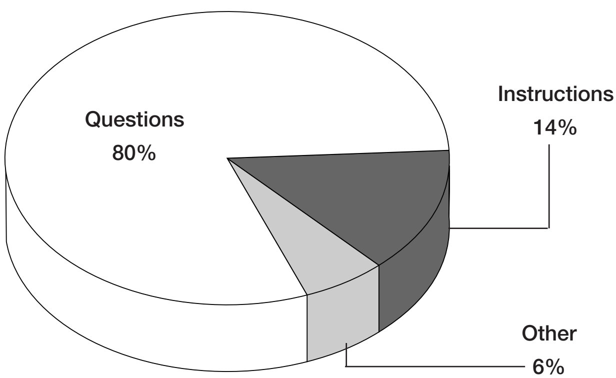


Figure 5.4: Categories of teacher–student interactions (n = 2980)



Teacher-student questioning

The nature of the interactions in which teacher and students are involved in the classroom is of central importance. Analysis of the twenty lessons revealed that questioning is the dominant mode of interaction between teacher and student. Teacher-student questions accounted for almost 80 per cent of the total teacher-student public interactions. The remaining interactions comprised either instructions to students or organisational or social exchanges (Figure 5.4). Teachers tended to use questioning to ensure that students were equipped with facts and procedures. The teacher's role was to demonstrate and explain while the role of the student was to memorise and practice.

The Nature of Teacher Questioning : Drill and Recitation

In their analysis of active teaching, Good and Brophy (2000) identify a range of questioning procedures in classrooms. Among these are drills or fast-paced review questioning which is designed to test or reinforce knowledge of specific facts. In such questioning the emphasis is on obtaining the right answer, and questioning tends to move at a brisk pace. Another form of questioning is recitation activity questioning. This includes questioning that occurs between presentation segments of lessons, questioning during periods in which teachers are going over the material, board work, and questioning occurring in the process of preparing students for assignments. Recitation activity questioning is not all of a kind however: it can vary in pace and cognitive level.

A third major form of questioning is discussion questioning which is designed to stimulate students to respond diversely at higher cognitive levels. Such questioning tends to move at a slower pace and the emphasis is on developing insights and implications. There may be acceptable answers to questions and no single right answer (Good and Brophy, 2000).

Examination of the teacher-student questions in the twenty mathematics lessons shows that, in keeping with the traditional mathematics style, questioning falls into either drill/fast-paced review questioning or recitation-type questioning. Further examination reveals that these two types of questioning tend to occur in different phases of the lesson. Specifically, drill questioning is largely confined to student practice phases such as homework or revision phases. Recitation-type questioning occurred mainly during the explanation and demonstration phases of the lessons. The absence of discussion questioning across all lessons is evidence of the strong traditional approach to the teaching of mathematics in the classes observed.

Drill Questioning

When drill procedures are utilised, questioning moves at a brisk pace with an emphasis on obtaining the 'right' answer. In a homework correction phase, for example, the teacher may ask the students to call out the final answer to each problem. In such a situation the teacher may correct a large number of homework problems in a short period of time.

The following extract is an example of drill-type questioning. It involves a very experienced male teacher in a designated-disadvantaged vocational community school located in a rural area (Blackstairs (VCC Fr D)). This was the second lesson with a mixed group, 51 per cent of whom were girls. The school is located in a rural area and one third of the class is from a middle-class background. The class achieved a high mean score of 27.2 out of a possible 40 on the TIMSS-related mathematics test.

Co-ordinate geometry is the topic of the lesson. The teacher is correcting ten homework problems assigned to the students the previous day. In each problem the students were asked to find the midpoint of a line. Throughout this phase, students were called on to give the correct answer to each problem. As each answer was given the teacher checked to see how many students got the correct answer and then moved on to the next homework problem.

Illustrative Vignette: Drill Questioning

Time code (minutes:seconds)	**Activity**	Homework Questions
		(Texts and Tests I Exercise 27C p. 376 Question 2) Use the midpoint formula to find the midpoint of the line segment joining each of the following pairs of points: **1.** (2,1) and (4,3); **2.** (1,1) and (7,7); **3**. (1,2) and (3,6); **4**. (–2, 1) and (4,3); **5**. (1, –3) and (3,5); **6**. (–2,–3) and (4,–1) **7**. (0,4) and (–2,2); **8** (–2,0) and (4,0); **9**. (2,-3) and (–2, 5); **10**. (3,–2) and (0,–2).
3:35	Homework correction begins Teacher asks general questions about the homework, looking for specific difficulties.	*Teacher:* How many questions did we have? *Class:* Ten. *Teacher:* Ten questions for homework. (*Inaudible*) the answers will be at random. Get the midpoint of the following. Any difficulties in any of them? Did some of them come out as fractions? As halves? *Class:* The last one. *Teacher:* OK, the last one. OK, any difficult ones? We might do one or two of them on the board. Where will we start? We'll start at the back with Denise?

4:02	Teacher questions Denise on first homework problem.	*Teacher:* Read out the question for me please. Denise? *Denise:* Ah – 2, open brackets, 2 coma 1, close bracket, 4 comma 3, close brackets. *Teacher:* And the midpoint? *Denise:* Open brackets 3,2. *Teacher:* (3,2) (3,2). When you give me the answers in future will you forget about the brackets. We know you have them in, at least we hope you have them in, you don't have to put the commas as well. Read out the points and the answers.
4:29	Teacher moves on to next homework problem naming a different student.	*Teacher:* Alright, next? Shane? *Shane:* 4,4 *Teacher:* Is that the answer now? *Shane:* Yes
4:35	Teacher questions whole class.	*Teacher:* Alright we'll just take the answers then. Hands up all who got that 4,4 very good everybody got (4,4).
4:41	Teacher moves on to next homework problem asking Angela.	*Teacher:* Next one, the answer just? *Angela:* (2,4).
4:44	Teacher asks whole class question.	*Teacher:* Hands up for that one (2,4). We're doing well so far.

All of the homework problems were corrected in this way. Eleven of the thirty-two students were involved in this homework correction phase of the lesson, which lasted just over two minutes.

The second extract is taken from a designated-disadvantaged single sex boys' secondary school in an urban area (Liffey (SSB Fr D), second lesson). It involves a very experienced male teacher and a top-stream group, almost three quarters of whom are working class. The class achieved an above average score of 24.4 out of a possible 40 in the TIMSS-related mathematics test.

The excerpt is from the homework correction phase of the lesson. The teacher has broken down the problem into a number of steps, calling on either individual students or the whole class at different times to provide the answer to each part of the problem. Overall, the teacher spent just over five minutes correcting one of the two assigned problems. Even though this is a much more detailed correction of homework than the previous example, it again illustrates the use of drill questioning with an emphasis on obtaining the right answer and moving quickly through the problem.

Illustrative Vignette: Drill Questioning

Time code (minutes:seconds)	**Activity**	**Content**
1:08	Homework correction: whole class Homework Assigned: Q.5 and 6 *Exercises 12.2 on page 87: Q5: A man invests £850 at 6% and £1200 at $8^{1}/_{4}$%. What is the total interest gained on these investments after 2 years? Q6: Calculate the simple interest on £265 for $2^{1}/_{3}$ years at $3^{3}/_{4}$% per annum. Teacher corrects Q6 only with whole class	*Teacher:* OK. Enough is enough! Right the big problem created with <u>question number 6</u> in so far as the answer in the book is completely different or looks quite different to the answer that you would normally get, right. In <u>question **6**</u> **calculate the simple interest on 265 for 2 and 1/3 years at 3 and 3/4.** Now for anybody who didn't do it *(teacher pauses)*. Now for anybody that didn't get the answer, the people who wrote out the question that's good enough for an attempt mark in an exam but we are aiming higher for higher than just an attempt marks, OK. So when we're doing these questions as we said <u>the principal by the time by the rate over 100</u>, this is question 6 – the one that's causing the problems.
	Teacher questions Brian.	*Teacher:* The principal in that particular question is ?
2:01	Brian replies.	*Brian:* 265
2:03	Teacher continues.	*Teacher:* 265, right so the interest is equal to 265 multiplied by the rate or the time, put the time second (*Teacher is writing this on the blackboard)*
2:12	Brian replies.	*Brian:* $2^{1}/_{3}$
2:14	Teacher continues.	*Teacher:* $2^{1}/_{3}$ times the rate?
2:17	Couple from the class shout up.	*Class:* 3 and $^{3}/_{4}$
2:21	Teacher continues, asks whole class question.	*Teacher:* All over 100, now this is one of the ones who warranted an asterisk, the reason being that there were big numbers that do not cancel out that nicely and you're left with a big multiplication question. Right. Now yesterday when we were dealing with these what did I tell you to do with them?

		$\frac{265 \times 2^1/_3 \times 3^3/_4}{100}$
2:35	A lot of students from the class answer up.	*Class:* Turn them into top heavy fractions.
2:37	Teacher continues.	*Teacher:* Top heavy fractions, right Leo! So that as a top heavy fraction is?
2:41	Couple from class mutter.	*Class:* $^7/_3$
2:43	Teacher replies.	*Teacher:* Good lad! Leo!
2:45	Leo replies.	*Leo:* I didn't say nothing.
2:47	Teacher continues.	*Teacher:* Did you not? (*sarcastically*) 265 multiplied by 7 over 3 *(muttering going on in the classroom*). Right Billy?
2:51	Billy enquires.	*Billy:* Yeah?
2:53	Teacher asks.	*Teacher:* $3^3/_4$?
2:54	Billy answers.	*Billy:* $^{15}/_4$
2:56	Teacher continues (writing on the blackboard).	*Teacher:* $^{15}/_4$ and you have 100 on the bottom again. Now if you look at those numbers very little cancel out, the reason being. Well you can go 3 into 15, 5 times, this 265 over 100 you can do a little bit with that, by doing something with it – changing the 100 which is a very easy number to divide by. So what we've got here is 265 by 7 by 5 over 100. So if you want to cancel out you can. That into that goes? $= \frac{265}{100} * \frac{7}{3} * \frac{15}{4}$ Cancel down (1) $\frac{15}{3}$ = 5 (15 = 5 and 3=1) (2) $\frac{5}{5}$=1 and $\frac{100}{5}$ = 20 (5=1 and 100 = 20) (3) $\frac{20}{5}$ = 4 and $\frac{265}{5}$ = 53
3:31	Class replies.	*Class:* 20
3:33	Teacher continues.	*Teacher:* Go again and 25 by, sorry, 5 into this goes 53, so you've got 53 on the top by 7 divided by 16. Right, so if you're not into multiplication which some of you are not, take it down as far as you can. Now that gives you 53 by 7 OK? Seven 3s are 20?
4:01	Class answers.	*Class: 1*
4:03	Teacher continues.	*Teacher:* Seven 5s are 35 and 2?

4:06	Class answers.	*Class:* 37
4:07	Teacher continues. Mark has his hand up but teacher is writing on the board and does not see him. He gives up after putting hand up for 2nd time.	*Teacher:* So you've got 371, I think 5 by 7, that's right, yeah. So you've 371 and you want to divide that by 16. $= \frac{53}{4} * \frac{7}{1} * \frac{1}{4} = \frac{371}{16}$ *Teacher:* So clearly straightforward division after that so 16 in this part? Kevin?
4:24	Kevin offers answer.	*Kevin:* Twice
4:26	Teacher continues.	*Teacher:* Twice so that gives you 32, take off the 5, 16 into 51, Kevin?
4:34	Kevin replies.	*Kevin:* Twice.
4:35	Teacher encourages.	*Teacher:* Go again.
4:36	Kevin replies.	*Kevin:* Three times.
4:37	Teacher continues.	*Teacher:* Three 16s are?
4:40	Liam shouts up.	*Liam:* 48.
4:41	Teacher continues.	*Teacher:* 48 from 51 leaves you with?
4:42	Liam answers.	*Liam:* 3.
4:44	Teacher continues.	*Teacher:* 3, bring down the?
4:45	Liam answers.	*Liam:* 0.
4:48	Teacher continues.	*Teacher:* Right, so you've 16 into 30 goes?
4:50	Class answers.	*Class:* Once.
4:52	Teacher continues.	*Teacher:* Once, that gives you 16, take off, you're left with 14, 16 into 140?
4:56	Class replies.	*Class* 9
4:57	Teacher continues.	*Teacher:* 9 times, nine 6s are 54, nine 1s are 9 and 5 are 14 so it's too high, but not very high because in questions such as this you're going to be left with a decimal part of a penny. And if you're left with a decimal part of a penny you'll be bringing it to the nearest penny anyway. So it's almost 19 so you can leave it 19 anyway. OK? So that the question is one of the ones where the instruction is at the beginning of the exercise was <u>to the nearest penny where necessary</u>.

Long division:

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     23.19
16)371
   32
    51
    48
     30
     16
     140
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Teacher: Now after that, that's the hardest one that you will get, very, very rarely that you will have a situation whereby that would come up in any exam, very rarely you would you come across that example even if you were talking about ordinary maths. Ok, any question on that?

Recitation Type Questioning

In the twenty mathematics lessons, recitation type questioning occurred mainly in the explanation or demonstration phases of the lesson. In the presentation of a new topic, the problem was broken down into a number of steps and the students were questioned in relation to each step. Unlike drill questioning, the teacher took a number of different answers from the students at each step before continuing the demonstration. This recitation type questioning also tended to move at a slower pace than drill questioning. However, this type of questioning is again very much in keeping with the drill and practice methodologies being employed, emphasising the importance of procedural knowledge in the traditional mathematics classroom.

An example of this type of questioning is seen in the first lesson observed in Blackstairs ((VCC Fr D); see Appendix 5 for extract from the class transcript). The lesson involves a demonstration by a male teacher to a non-streamed mixed group.

The topic being covered in this lesson is co-ordinate geometry: plotting co-ordinates and the midpoint of a line. In this excerpt the teacher is demonstrating how to find the midpoint of a line, which is a new topic for this class.

The teacher has drawn X and Y axes on the board and labelled them, and has instructed the students to do the same in their copies. He has taken two points (3,2) (–1, –2), and joined them up and has asked the class to find the midpoint. The teacher stated: 'If you have an accurate diagram drawn you probably will have a good indication as to what the mid-point is going to be anyway.' The teacher then asked the class to estimate (from their diagrams) where the midpoint is. The class answered (1,0). At this point the teacher stressed that diagrams are used as a guide and explained that there is a formula for the midpoint of a line:

> Diagrams are only used as a guide. There are little formulae, unfortunately, that we have to know. We have to learn the formula. The proper way to do it is to use the formula.

In this extract the teacher demonstrates the formula and where it comes from. The demonstration is interspersed with whole class and individual questioning.

The extract (Appendix 5) illustrates the use of recitation questioning. The teacher involved the class in the demonstration of the application of the formula and encouraged the class to suggest answers: 'Hands up, right, hands up? What's on the clock?[1] Hands up? Come on, come on, more of you than that! Come on – what is on the clock? Later in the lesson the teacher continued this encouragement, stressing that it does not matter if wrong answers are given:

> I'm going to take a few answers. We're going to have wrong answers I know we are but so what? What about it? You can guess it, if you're not too sure. You're guessing it.

Despite the teacher's assertion that it was acceptable to give wrong answers, it was only when the 'right' answer was given by a student that the teacher investigated the question further: 'Where did you get the 15, Alex?' Little attention is given to the method of arriving at the incorrect answer and the reasoning behind that procedure.

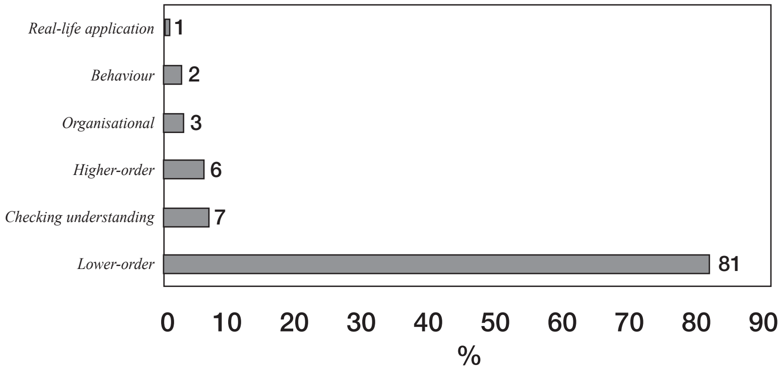
The importance placed on procedural knowledge was also evident later in the lesson when the teacher invited a number of students up to the board to work through examples using the formula. During these practice examples he told the class that there is 'no need to draw the diagrams every time' but he stressed the importance of knowing and learning the formula: 'The formula must be written down every time'.

Level of Questioning

Teacher-student questioning has been differentiated in the literature into low level or high level cognitive activities. Low level activities require the student to apply a routine procedure to find an answer (Fennema, 1987). Often the student must recall specific facts or use a memorised algorithm. In this way the student is being taught a mechanical procedure for arriving at a solution. In high level cognitive learning, the mental demands are greater, requiring the student to understand, interpret or apply mathematical knowledge. To solve a high level problem the student must deduce how to solve it (ibid).

In both drill and recitation type questioning, the vast majority of teacher-student questions were low level knowledge or comprehension questions. Analysis of all teacher-student questions throughout the twenty mathematics lessons show that almost 82 per cent were lower order questions. Higher order questions comprised just over 5 per cent of all teacher-student questions. The remaining teacher-student questions were made up of behaviour questions, real life applications[2], checking student understanding and organisational questions (Figure 5.5).

Figure 5.5: Types of teacher-student questions (n: 1451)



Below are some examples of lower order teacher-student questions from two lessons, again illustrating the emphasis on procedural learning.

Examples of teacher-student low-level questioning

Liffey (SSB Fr D), second lesson: The lesson, taught by a male teacher, involves the continuation of a new topic covered on the previous day. The topic is simple interest. This extract occurs at the beginning of the lesson in the homework correction phase. The problem being corrected involves calculating simple interest. The teacher has broken down the problem into different stages. This part of the procedure involves long division.

Teacher:	So you've 371 and you want to divide that by 16. So clearly straight forward division after that so 16 in this part?
Kevin:	Twice.
Teacher:	Twice so that gives you 32, take off the 5, 16 into 51, Kevin?
Kevin:	Twice.
Teacher:	Go again.
Kevin:	Three times.

Errigal (CS Fr), first lesson: The topic being covered in this lesson is algebra: equations with fractions. The topic is being continued from the previous day. The teacher is correcting one homework question:

$$\frac{6}{3x+2} - \frac{5}{3x-2}.$$

She has broken down the problem into different steps. This part of the procedure involves addition:

Teacher: And over here then – minus 12 and minus 10 – Elaine, what will that give me altogether?
Elaine: Minus 22.

Higher order questions mainly included those prefixed with how or why in relation to mathematics method or procedure. Examples of high level questions asked by teachers follow. It should be noted that these are among the highest level of questions that we found in the course of our analysis of teacher questioning.

Examples of teacher-student high-level questioning

Barrow (SSG F), first lesson: The topic being covered in this lesson is quadratic expressions with mixed signs. In this excerpt the teacher is demonstrating how to factorise quadratic expressions when the terms are negative. Through teacher questioning, the class has arrived at the final solution (x+2) (x-3).

Teacher: … does it really matter whether I write (x + 2) first followed by (x – 3) or the other way around?
Class: No.
Teacher: …not at all! Why does it not matter?
Class/Teacher: Because the product is going to be the same either way.

Lagan (SC Fr), first lesson: The topic being covered in this lesson is length of a circle. It is a new topic for this class. The teacher has worked through a number of examples. In this extract she has moved on to a more difficult example and is asking the class for suggestions as to how to approach the question.

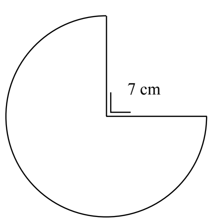
Teacher: Have we any idea how we'd do this?
Student: Divide by 2
Teacher: Divide what by 2, eh, Mark?
Student: The answer, so 44 divided by 2.
Teacher: You divide the 44 by 2 to give you 22. So we know that the length of this circle is 44, yeah, so you're saying to me to divide by 2. Why are you saying that it sounds like a good idea? Why are you saying that?
Student: It's the opposite of the way you get the length.
Teacher: Yeah, you're doing well, right you're saying divided by two.

Good and Brophy (2000) point out that although higher order questions are intended to elicit higher order responses, many students often respond at a lower cognitive level than the question demands. In many cases in our study, student answers to such questions are of a low cognitive level and the teacher either provides the correct answer, or asks further low level questions until the required answer has been reached. The students' responses to higher level questioning by teachers are indicative of the normal level of questioning in a typical lesson. The fact that students hesitate or mumble answers to higher order questions might suggest that they are more used to, and therefore more comfortable with, low level questioning requiring short or one word answers.

This is illustrated in the following extract. This example concerns a free scheme secondary coeducational school located in a small town (Lagan (SC Fr), second lesson). It involves a demonstration by an experienced female teacher to a top stream group. Almost 52 per cent of the class are girls. Two thirds of the students are from a middle-class background. The class achieved a high mean score of 28.5 out of a possible 40 in the TIMSS-related mathematics test.

Illustrative Vignette: Higher order question

Time code (hours:minutes:seconds)	**Activity**	**Lesson Text**
1:18:56	Demonstration Example 3: Q4(iv) Find the perimeter of each of the following shapes:	*Teacher:* OK, we're going to go on today with the ones where you're given a shape that involves a part of a circle, and you want to work out what the circumference or what the perimeter of those kind of shapes are, and we did one the last day where they gave us half of a circle and a quarter of a circle, so what we want to look at now is say one with three quarters of a circle, like this, with a radius of 7. How would you work this one out? *(Teacher draws three quarters of a circle on the board.)*



1:19:27	Teacher asks Frank a question.	*Teacher:* Well Frank, what do you think, what would you do with this one, if you're looking for the perimeter, that's what we're looking for, so what will we do?
1:19:37	Frank answers question.	*Frank:* eh? *Teacher:* What fraction of a circle is it? *Frank:* Three quarters *Teacher:* Yeah good, it's three quarters of a circle. How do you know it's three quarters? *Frank:* Because *(hesitates)*... *Teacher interrupts:* Is there any hint there that it is actually three quarters exactly?
1:19:53	Teacher asks Lorna same question.	Lorna?
1:19:54	Lorna answers question.	*Lorna:* It's the little line. *Teacher:* The little line means? *Whole class answer:* That it's a right angle. *Teacher:* That it's a right angle, so it's 90 degrees OK. So 90 is one quarter, so there's three quarters there. So we're going to have to do three quarters of a circle.

The teacher is demonstrating how to find the perimeter of parts of a circle. Here, the teacher asks a higher level question about the fraction of the circle: 'How do you know it's three-quarters'. The first student asked hesitates; the teacher reverts to a more procedural approach moving to another student who gives the required 'correct' answer. Thus while the teacher begins the topic with a higher order question, she returns to a more procedural approach as it becomes clear that the students are not really engaged with this type of question. Here we see how the students are responding at a lower cognitive level than the initial question allows.

Teacher instructions

Teacher instructions accounted for 14 per cent of all public interactions throughout the twenty mathematics lessons. The main types of instructions issued were mathematics related. Such instructions involved the teacher telling the class what to do next, or instructing the class to follow certain procedures or to copy worked examples from the board into their copies. Non-learning instructions included organisational or behavioural instructions.

The nature and scope of the instructions given indicate the high level of teacher control in the mathematics classrooms. Instructions from teachers were definitive so that students had little opportunity to make an input into the organisation of their own learning environment. On the whole, students obeyed the instructions, without question.

The nature of mathematics related instructions also point to assumptions of certainty and truth in the epistemological approach to mathematics. Instructions were given for operationalising procedures for resolving mathematics problems, with an emphasis on the correct way of doing things. These procedures were accepted by the students without question. Some examples of teacher instructions follow.

Illustrative Vignette: Mathematics related teacher instructions

Liffey (SSB Fr D), second lesson: In this lesson the teacher is continuing the topic of simple interest from the previous day. Today's lesson is concerned with finding the principal, time and rate. The teacher has just run through the formulae for finding each of these. In this extract she is about to do some practice examples but before this she gives the following instructions with regard to remembering the formulae.

'So you've three new formulae all derived from the one formula, and all those are given as an exception in the book. OK, now after a while when you've gone through these a few times, if you write them down – as you're going along you won't have any difficulty in learning them and remembering them, which is more important, as the further you go on you will not have these formulae given to you OK. …. Now the most important aspect of any of these questions you are dealing with from here on in is <u>to identify whether you are dealing with the principal or the time or the rate</u> OK, whichever you are dealing with. And remember the fourth part of the equation is the interest. So be very careful with how you do the questions.'

Suir (SSG Fr D), second lesson (bottom stream): The topic being covered in this lesson is statistics: bar charts. It is a revision class. The teacher has set the class work from a revision sheet. She is walking around the room and checking the students' work. Before proceeding to the next topic of pie charts the teacher issues these instructions in relation to bar charts.

'You all should nearly know how to do all the bar charts. They're the ones that you'd need the bars the same thickness all the way through, … You need to be very consistent … need to be consistent with your marks up along this side … If you start with 2s, you must go up consistently in 2s, if you start with 5s, you must go up in 5s. OK and along this side, make sure that you label your axes so think every time you're going to draw a chart for someone – someone outside the class wants to be able to read it. So you need to be able to show them on your diagram.'

Blackstairs (VCC Fr D), second lesson (mixed group): The topic being covered in this part of the lesson is co-ordinate geometry. The teacher has demonstrated the formula for finding the distance between two points. Before beginning to work on some practice examples the teacher issues the following instructions with regard to the formula.

And that's the <u>formula</u> for the <u>distance between two points</u>. If $a(x_1, y_1)$ and $b(x_2, y_2)$ are two points, then | ab | is: $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$. So any two points you get, all you do is, you don't even need a diagram for them. Use that formula here … here … If you had a point like this, very roughly now (3, 5) and oh whatever (4, 6). What's the distance between those two points? You just draw your X_1 Y_1 X_2 Y_2. Whatever you call X_1 you must call its partner Y_1. In other words – X_2 – sorry! That's a mistake there. Let me call X_2 it should be Y_2. There's nothing stopping you from calling that one X_2 as long as you call its partner Y_2. The order doesn't matter. If it's X_1 it must be Y_1. So you just go on the distance between those, the square root of $X_2 - X_1$. Write the formula down every time. You square that, plus $Y_2 - Y_1$

Instructions were also issued by teachers to regulate student attention levels in class.

Illustrative Vignette: Behaviour related instructions

Nore (SSG Fr), frst lesson (mixed group): The topic being covered in this lesson is statistics: bar charts. It is a new topic for this class. The teacher is working through some examples from the textbook. At this point he has instructed the class to do a simple calculation. All of the students except one girl commence the calculation in their copybooks.

Teacher: So have a go, quick add them all, quick.
Not in your head Grainne, on paper. This is recorded for posterity only if you get it wrong it'll be back to haunt visit you in 50 years' time.

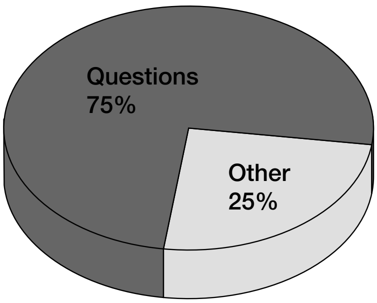
Liffey (SSB Fr D), second lesson (top stream): The topic in this lesson is simple interest. The teacher is working through an example on finding the rate. In this extract the teacher asks Tony a question. He has already reprimanded this student a few times for misbehaviour.

Teacher: Tony! Right rate is equal to, from the formula down there, yeah… Come on it's in the book. 100 multiplied by? Have you got the right page even Tony? *(Teacher sounds annoyed at this stage.)*
Tony: Yes!
Teacher: Try page 88 there Tony. Yes thank you very much, it's good to see you paying attention again, yeah. Rate? Tony? *(There is laughing and giggling in the classroom.)* Today some time.

Student-teacher interactions

As noted above, student-initiated interactions accounted for just 4 per cent of all classroom interactions. The vast majority of these – just less than three quarters – comprised questions. The remainder consisted of other interactions (Figure 5.6).

Figure 5.6: Total student–teacher interactions (n = 106)



As in the case of teacher-student questioning, the majority of student questions were mathematics related and were of a low cognitive level. Below are some examples of student-teacher questions.

Student-teacher questions

Lee (SSB F), second lesson: The topic being covered in this lesson is quadratic equations. It is now about halfway through the lesson, the homework correction phase. The teacher has broken down the problem into different steps. This part of the procedure concerns multiplying 2 brackets **(10+2x) (8+2x).**

Student: Did you multiply that out by saying the first thing in the first bracket by all in the second bracket?

Teacher: That's how you multiply two brackets, yes. First thing in the first bracket, by all in the second bracket?

Student: then use 0…?

Teacher: *(interrupting)* Same as you normally do. Multiply out and factorise your answer then.

Lee (SSB F), second lesson: This excerpt occurs towards the end of a lesson on quadratic equations. The teacher is setting homework. She has called out a homework problem for the next day. The problem mentions consecutive numbers. At this point she asked the students to give examples of consecutive numbers. Having done this she seems satisfied that they understand this term. Moments later a student asks the following question:

Student: For the second number, what is a consecutive number?
Teacher: A consecutive number is just numbers straight after each other. If the question said 3 consecutive numbers, that would be 1,2,3,4,5,6. But it says consecutive, even numbers so it is the next even number each time. 2,4,6,8. Right?

Nephin (VCC Fr), second lesson: The topic being covered in this class is algebra: removing brackets. It is the continuation of a topic from a previous lesson. While the teacher is checking homework the students have been instructed to work ahead on questions from their textbook which concern removing brackets and multiplying.

Student: Does a minus by a minus give a plus?
Teacher: If you're multiplying a minus by a minus give it plus, yes.

Student-initiated other public interactions included public comments directed by students to the teacher during the mathematics lesson. These involved comments such as pointing out a teacher's mistake, informing the teacher of an organisational problem or a problem they have encountered with the mathematics, or making a smart/humorous remark. Examples of some student-teacher comments follow.

Student-teacher comments

Lagan (SC Fr), first lesson: The topic being covered in this lesson is length of a circle. The teacher is working through examples from the textbook. She has made an error, working out the problem based on the length of the diameter instead of the radius.

Emlyn: Eh, miss.
Teacher: Yeah
Emlyn: That's the diameter
Teacher: That's the diameter, well pointed out to us. Good man, Emlyn! Alright, so if it's the diameter that's 10 what should we have done there?
Class: 5
Teacher: We should have used the radius as 5 – that's where it shows to read the question.
Well done Emyln! OK – I didn't notice that! So it says (*reads question from Texts and Tests 1*) using 3.14 as the approximate of pi, calculate the length of the following circles giving the length of the diameter in each case. Is that OK? So, what should I have done here? Instead of using 10 we should have used?
Class: 5

Nephin (VCC Fr), first lesson: This is a revision class covering bills and taxable income. In this excerpt the teacher is setting up an example to explain how to calculate taxable income and is interrupted by a student.

Michael:	We did this before.
Teacher:	Hmm?
Michael:	We did this in first year.
Teacher:	I beg your pardon Michael?
Michael:	Nothing sir.
Teacher:	You're muttering there again, don't be shy *(class laughs)*. It's not like you to be quiet.

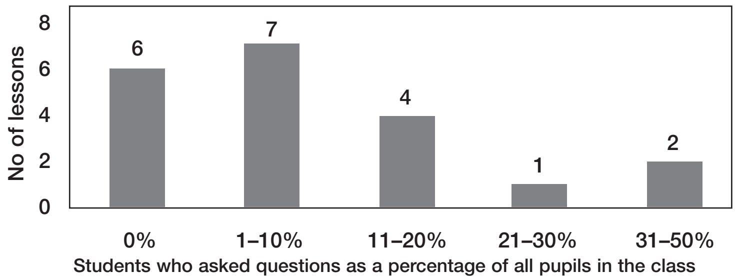
Nephin (VCC Fr), second lesson: In this extract which occurs at the end of a revision lesson, the teacher has just finished working through an example of how to calculate bills.

Michael:	Sir, I got that one wrong.
Teacher:	Did you? The multiplication part?
Michael:	No, the taking away part.
	(Teacher goes over to Michael and looks at his copybook.)

Student-teacher questioning

An important consideration when examining student questioning is to determine the number of students actually involved. Figure 5.7 shows that in six lessons there was no incidence of student-teacher questioning. In a further eleven lessons, student-teacher questioning involved 20 per cent or fewer of the students in the class. In the final three lessons, between a quarter and a half of students in the class initiated questions of the teacher. There were no classes in which half or more of the students asked questions therefore, and in only three of the twenty did 21-50 per cent ask questions.

Figure 5.7: Student-teacher public questions (n = 79)



What was clear from the video analysis was that students were not encouraged to ask questions, and few did. Moreover, it was boys who were most likely to initiate questions with teachers, be it in coeducational classes or when single sex classes were compared. (Gender differences in student questioning and classroom participation will be discussed in more detail in Chapter 6).

Overall therefore, student-teacher initiated interactions were confined to a small number of predominantly male students. In four of the three single sex girls' classes, only one student asked a quesiton (Barrow and Nore), while there were only six students who asked questions in the eight coeducational classes observed (Lagan, Errigal, Mourne, and Blackstairs).

Table 5.1: Breakdown of student-teacher questions by lesson

School	Lesson	No. of students in class	No. of student-teacher questions	% of students in class who asked question
Barrow (SSG F)	1	28	0	0
	2	28	0	0
Nore (SSG Fr)	1	24	1	4
	2	23	0	0
Suir (SSG Fr D)	1	12	6	42
	2	10	3	20
Liffey (SSB Fr D)	1	23	3	9
	2	22	6	18
Lee (SSB F)	1	26	7	8
	2	26	13	19
Lagan (SC Fr)	1	30	1	3
	2	31	1	3
Errigal (CS Fr)	1	30	1	3
	2	30	0	0
Mourne (VCC Fr D)	1	19	2	11
	2	14	0	0
Blackstairs(VCC Fr D)	1	33	1	3
	2	32	0	0
Nephin (VCC Fr)	1	10	20	30
	2	10	14	50

Key: SSG F: Secondary girls', fee-paying; SSG Fr: Secondary girls', free scheme; SSG FrD: Secondary girls', free scheme designated disadvantaged; SSB FrD: Secondary boys', free scheme designated disadvantaged; SSB F: Secondary boys', fee paying; SC Fr: Secondary coed, free scheme; CS Fr: Community School, free scheme; VCC FrD: Vocational/Community College, free scheme designated disadvantaged; VCC Fr: Vocational/Community College, free scheme (where free-scheme represents non fee-paying status).

Student responses to teacher-student mathematics questions

Figure 5.8 shows that students mainly gave the 'correct' or 'right' answer in response to mathematics related questions from the teacher. These responses accounted for almost two thirds (65 per cent) of all student answers. 'Incorrect' responses accounted for just 11 per cent of student answers. A slightly higher proportion of responses (13 per cent) comprised progress reports: these included follow-on responses to teacher questions regarding 'correct' or 'incorrect' answers. Other categories included 'no answer/hesitation/mutter' and 'no chance to answer' (before teacher/other student intervened).

The teacher's reaction to 'correct' responses is illustrated in Figure 5.9 showing that teachers mainly acknowledged or accepted these answers without praising the student. 'Asking an additional question' of the student who provided the 'correct' answer was the next most common type of teacher feedback, accounting for almost one third (32 per cent) of all teacher feedback. Other types of feedback included the teacher checking with the rest of class to see who got a particular answer (3 per cent).

Figure 5.8: Student responses to teacher mathematics questions (Base: 1386)

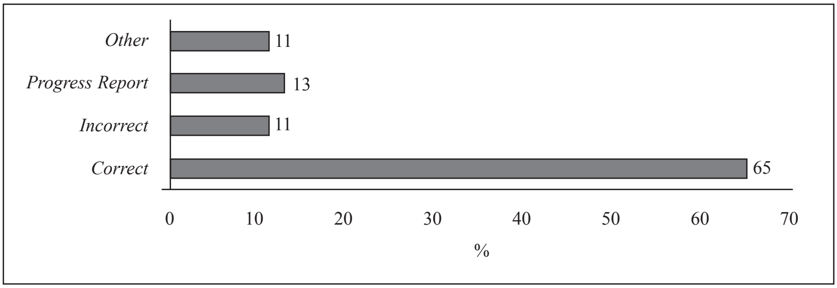
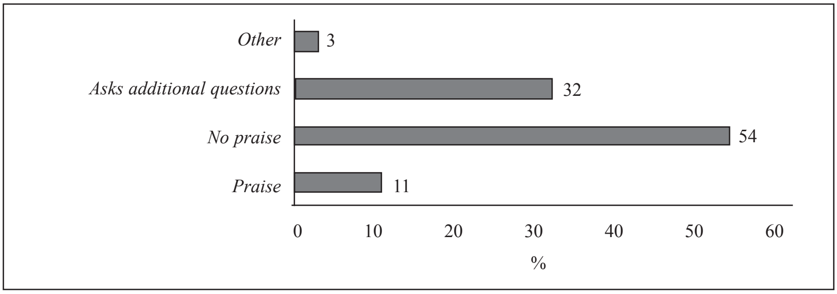


Figure 5.9: Teacher feedback to 'correct' student response (Base: 895)



Epistemological assumptions and related pedagogies

Mathematics was presented to students generally as a subject a) that had a fixed body of knowledge; b) that was abstract in character; c) that required demonstration of procedures rather than explanation; and d) that comprised discrete elements.

It was presented as a body of expertise that is transmitted directly from teacher to student, in the classic banking mode defined by Freire (1972).[3] Moreover, it was also characterised by what Bernstein (1977) has referred to as systems of strong framing and classification:[4] not only was mathematics defined as a discrete subject, and taught without relationship to other disciplines, it was also separated within itself (strong classification). In addition, students had little control over the pedagogical relationship, over what they learned or how they learned it. Teachers also exercised little control over content (strong framing).

Lessons were strictly organised in terms of particular topics: each theme was treated as a discrete entity be it quadratic equations with mixed (positive and negative) signs (Barrow (SSG F), first lesson); simple interest (Liffey (SSB Fr D), both lessons); or the length of a circle (Lagan (SC Fr), first lesson). Problems were identified within these topic areas, and in no case was there evidence of more than one method being identified and prescribed for solving the problem.

There was also little evidence of students being given a substantive explanation of the mathematics being taught: written demonstration of a single procedure for solving a problem was the norm; there were few examples of verbal explanations. Learning appeared to be defined primarily as a matter of memorising procedures and facts. Teachers generally demonstrated a procedure and then instructed students to practice the method. The objective was to ensure that students perfected their procedural skills, although such an objective was never overtly stated. There were very few examples in the lessons of teachers providing the students with a reason or explanation as to why they were studying a particular field of mathematics.

Much of the literature has highlighted the importance of developing understanding in mathematics (Fennema and Romberg, 1999). In order to understand the mathematics, and therefore to remember what has been learned, the student needs to be capable of making connections between ideas, facts and procedures. Analysis of lesson organisation in our twenty classes showed that a very small proportion of overall lesson time was given to making connections or explaining relationships in this way. The emphasis instead was on speed, in terms of covering a maximum amount of material in a lesson and being able to complete problems quickly. Such an approach reduces opportunities for discussion, an activity that may lead to greater understanding

An abstracted view of mathematics is what underpinned the teaching of the subject in all classes. Mathematics was presented as something separate from the outside world. There were few real life applications of mathematical concepts or principles. In only two of the twenty lessons observed was there any reference to the application of mathematics. Students were generally not given the opportunity to see how mathematics had applications in every day life.

Given teacher focus on procedural skills, it was not surprising to find that mathematics was taught in a didactic manner in all twenty lessons. This involved a combination of lecture and drill and practice of prescribed methods. Typically, the teacher lectured to the class as a whole and asked questions. Students watched, took notes or copied examples into their exercise books when instructed, and answered questions when called upon. There was little evidence of student-initiated interaction.

Discourse

There were three prevailing themes in the teachers' discourse in classrooms. First, it was evident that teaching for examinations (or more correctly, 'the exam', meaning the Junior or Leaving Certificate) was an overriding preoccupation in the teaching of mathematics. Second, mathematics itself was defined in binary, hierarchical terms as being either 'hard/difficult' or 'easy'. Third, student answers to mathematics questions were defined in a binary polarised code as being either 'right' or 'wrong'.

'The Exam'

In 6 out of the 10 schools, the teacher mentioned the exam at least once over the course of the two observed lessons. Examples of references to the exam include the following:

> *Teacher:* So the first thing then, if you are in an **exam** how do you recognise this type of sum? (Errigal CS Fr, first lesson)

> *Teacher:* Now of course if we are really diligent, how can we check to make sure that we are right particularly the day of the **exam** – we won't just leave the answer and say 'hope for the best' would we – what would we do? (Barrow SSG F, first lesson)

> *Teacher:* Alright – Richard?
> *Richard:* Miss, I got it all right to the end and then I forgot to do that.
> *Teacher:* To go back and get the second one? Right, well you'd loose a mark for that in the **exam**. (Lee SSB F, first lesson)

These excerpts imply that achievement in the exam (in this case, the Junior Certificate) is the main objective for learning mathematics. The goal is to 'learn mathematics' in a way that will facilitate achievement in the examinations. In this context, teachers are required to teach 'to the exam', a view which was expressed by the ten teachers in the interviews (see Chapter 9 for a more detailed discussion of this issue). In keeping with this finding, there is little reference in the lessons to any other rationale for studying mathematics, for example for fun, for its intellectual challenge, for broadening the mind, or for use in everyday life.

'Right' or 'wrong'

There was a strong emphasis on getting the 'right' answer in all mathematics classes. The focus was not on the rationale for resolving a problem in a given manner, or on different methods for resolving it; getting the 'correct' answer was the primary objective. All of the lesson transcripts contain numerous references to 'right/correct' and 'wrong' answers. The following excerpts illustrate the context:

Teacher: What are we trying to find here Emma?
Emma: Emm, what x is equal to.
Teacher: What x is equal to. So you need to sort out a bit don't you?
Emma: Put a line down the middle of the x or the equals.
Teacher: The equals, OK. (*Teacher draws a line down from the middle of the equals sign)*:

$$4x - 2 + 9 - 3x = 12$$

Teacher: Right or wrong? *(Teacher points to 4x.)*
Emma: Right. *(Teacher places a tick over 4x.)*
Teacher: Right or wrong? *(Teacher points to –2.)*
Emma: Wrong.*(Teacher places an x over –2.)*
Teacher: Right or wrong? *(Teacher points to +9.)*
Emma: Wrong. *(Teacher places an x over +9.)*
Teacher: (Teacher points to –3x.)
Emma: Right. *(Teacher places a tick over –3x.)*
Teacher: (Teacher points to 12.)
Emma: Right. *(Teacher places a tick over 12):*

✓ ✘ ✘ ✓ ✓

$$4x - 2 + 9 - 3x = 12$$

Teacher: Now what do we do with the ones that are right then?
Emma: Emm, put them down. (Errigal CS Fr, second lesson)

Teacher: Yes, she is absolutely right, and we won't go into all the nitty gritty as to why that is right because we DO KNOW now, don't we?
Class: Yeah! (Barrow SSG F, first lesson)

The language employed by teachers indicated a strong adherence to certainty about mathematical procedures and solutions. There appeared to be little room for the discussion or exploration of alternatives to the prescribed methods. Moreover, being 'wrong' or making mistakes did not appear to be part of the learning process: students were encouraged to get the 'right' answer. Being 'wrong' was something that students feared. Such fear made them unwilling to experiment or even to participate publicly in working out answers to questions (see Chapter 10 below for a further discussion of this point)

'Hard' or 'Easy'

The language used by teachers to describe their subject suggested that they defined mathematics in polarised, hierarchical terms as 'difficult' or 'hard', 'easy' or 'simple'. Classifying a mathematics problem as 'hard' implied immediately that the student was likely to have difficulty resolving it, or that she or he might not be able to resolve it. This automatically created a barrier between the student and the subject. Equally, references to a problem being 'easy' was likely to be alienating for students having difficulties understanding or keeping up with others in the class. It was likely to reinforce a student's sense of incompetence if she or he were unable to do the 'easy' tasks.

Yet use of this type of language was common in the case-study lessons.

> *Teacher:* Now shall I start now with a slightly harder question. Now let's see how we perform on the slightly harder ones … OK, that's harder because there is a minus in it you see – so we must pay attention to the detail – this is the problem. (Barrow SSG F, first lesson)

> *Teacher:* Our statistics today is going to be nice and easy … So this is our bar chart – the first type we've come across and we have bars – now notice the bars are all equal widths but different heights – right easy enough! (Nore SSG Fr, first lesson)

> *Teacher:* Now we have 9 per cent so we multiply that by £3.40 and multiply the answer by 4. It's very simple – simple mathematics – it's not difficult stuff. (Liffey SSB Fr D, first lesson)

> *Teacher:* It says, a carpet 8 metres by 10. You see it on the board! Pay attention to the board while we're doing it to see where you're making your mistake. This one is quite difficult so you may not be able to do it. (Lee SSB F, first lesson)

Conclusion

The analysis of the video material on classrooms revealed three important findings in relation to the teaching of mathematics. First, it is evident that mathematics is taught within a clearly defined essentialist epistemological framework. It was a classic example of what Bernstein (1977) has identified as a subject with strong classification and strong framing. Mathematics was generally presented as a fixed body of knowledge, separate from other subjects. Little time or attention was devoted to the problem-solving nature of mathematics, to the application of mathematics in the world, or to alternative methods of solving mathematical problems, other than those prescribed by the text or the teacher. Learning for the examination was the central task.

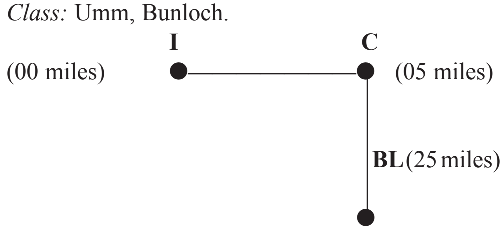
The pedagogical style that prevailed in the teaching of mathematics both reflected and reinforced the epistemological principles underpinning the subject matter being presented. Classes were strongly teacher directed, with teachers generally using a didactic approach to the presentation of material. Teacher initiated interactions with students comprised 96 per cent of all public interactions in the twenty mathematics classes observed. Teachers were far more likely to use lower order than higher order questioning, and to use drill and repetition rather than discussion-type questions, to teach mathematical concepts. The work programme of the class therefore was strongly teacher determined, with a resultant lack of student participation in the organisation of their own learning.

Finally, the discourse of mathematics classrooms was remarkably uniform. There were regular references to 'the exam'. The subject matter was defined in binary codes as either 'difficult' or 'easy', 'hard' or 'simple'. Answers were classified also along polarised lines as either 'right' or 'wrong'. The subject of mathematics was one therefore in which there was a clear judgement of the student's work, a judgement that was often made in public. This implicitly, and at times explicitly, judgemental atmosphere created anxieties and tensions for students in relation to the subject of mathematics itself.

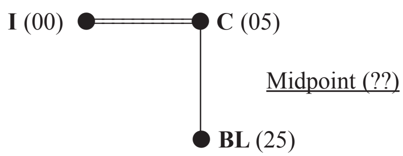
As noted in Chapter 4, however, the epistemological and pedagogical frames utilised in the teaching of mathematics is but a variation on a wider theme. While mathematics is arguably more essentialist in content, and is taught in a more didactical style than other subjects, a system of strong framing and classification characterises most subject teaching in Irish second level schools. School subjects, with some minor exceptions, have clearly defined boundaries and content; they are not presented in an integrated manner. In addition, the syllabus is presented largely as a set of certainties or skills 'to be grasped' by students for 'the exam'. While there are variations in epistemological assumptions and pedagogical practices, and in the discourses employed across subjects (as can be seen below in our analysis of English classes in Chapter 8), there are also several remarkable similarities between them (Lynch and Lodge, 2002).

Appendix to Chapter 5

Illustrative vignette – recitation questioning (from Blackstairs (VCC Fr D))

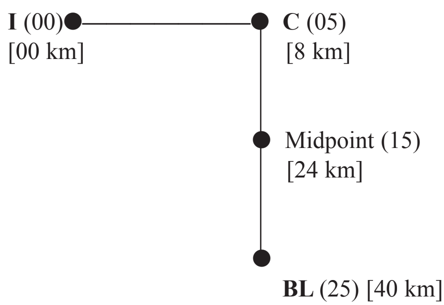
Time Code (minutes:seconds)	**Activity**	**Content**
10:58	Explanation/ demonstration: teacher-centred	*Teacher:* What is the formula for this? OK – so I'm going to rub off what I have over here and we'll try and explain and find out where this formula comes from. We'll start off over here. Don't write this down now. At a particular point, at a venue.
11:26	Explanation/ demonstration: questioning whole class	*Teacher:* Anyone here from Inis? No, hands up, two! OK we're driving from Inis to over here to C**,** which is? *Class****:*** Cluan *Teacher:* Cluan, right! And we'll start off here. Press the milometer button here at 00. Start there at nought. How far is it from Inis to Cluan? About? *Class:* 4 or 5:  *Teacher:* Is it 3 or 4 or 5, say 5 miles from here? OK – so it's 5 to there. So you're passing through Cluan and you see 5 miles on it now you go south towards a big town south down here – BL – what's BL? *Laughs from class* *Class:* Umm, Bunloch.  *Teacher:* Right now when you arrive in Bunloch you see on the milometer that it is 25, all right. On this route here just about half way, a very important place there its called? *Class****:*** *Students answer (inaudible)* *Teacher:* What's it called?

Class: Students laugh.
Teacher: Why is that important?
Class: Because you live there.
Teacher: Because I live there!



12:50	Explanation/ demonstration: questioning individuals. Teacher asks John.	*Teacher:* So as you pass this particular here point – special place there *(laughs from class, teacher pointing to midpoint between C and BL)* – you look at the milometer just there, what's on the clock? Shhh – think about it. Hands up, right, hands up? What's on the clock? Hands up? Come on, come on, more of you then that! Come on – what is on the clock? You have Inis (00), Cluan (05) and Bunloch you have (25). What's on it there, right in the centre of it – when you're stopping for a cup of tea? *(Laughter)* Right, hands up, come on, there are a few, come on, hands up. Yes, you have your hand up, so you think you know it?
13:54	John answers teacher's question.	*John:* 10 miles
13:56	Explanation/ demonstration: questioning whole class	*Teacher:* 10 miles. Hands up all who agree with him, thinks it's 10? One, two, three – three people for 10! *Teacher writes this on the board.* **10 (3)**
14:08	Explanation/ demonstration: questioning individuals Teacher asks Michael question.	*Teacher:* Any other answers? *Michael:* 17 and a half.
14:11	Explanation/ demonstration: questioning whole class	*Teacher:* 17 and a half. Anybody else think it's 17 and a half? *Class laughs.* *Teacher:* Nobody, nobody, not much support there.
14.19	Explanation/ demonstration: questioning individuals Teacher asks Gary question.	*Teacher:* Hands up again, yes Gary? *Gary:* 15 *Teacher:* 15 – Hands up all who say it's 15. A lot of support there Gary! Where did you get the 15 Gary? *Gary:* Because it's five over to there. *Teacher:* Over to Cluan – right!

		Gary: And 25 total *Teacher:* Right! *Gary:* So take away – take away the 5 from the 20 and you're left with 20 – *class laugh at mistake* – and half way – I mean take 5 from 25 and you're left with 20 – and half way between that is 10 and 5 is 15.
14:50	Explanation/ demonstration: questioning whole class	*Teacher:* Right, yeah it's a roundabout method *(laughter from students)*. Yeah – any other way cutting down to just half of this, half of say 25 if you add, what 25 and?
15:01	Explanation/ demonstration: questioning individuals Vicky volunteers answer to teacher's question and teacher then asks this same question of Vicky.	*Vicky volunteers answer:* 30 *Teacher:* Add what Vicky? *Vicky:* Add 25 and 5 *Teacher:* Add 25 and 5 and what do you get? *Class answers:* 30 *Teacher:* 30. And half it is 15, right, grand – 15 is correct! Right we got it! So you added, what will we call it, X_1 (00) for the minute and that's X_2 (25). So we added X_1 and X_2 and then halved it right.
15:25	Explanation/ demonstration: questioning whole class Teacher asks whole class question.	*Teacher:* Supposing you were driving a Japanese car (*laughter)* it's not in miles now sure its not. What's it in? *Class:* Kilometres *Teacher:* Kilometres so, well start it off at 00. How many kilometres in 5 miles? *Class:* 8 *Teacher:* How many? 8 is correct.
15:46	Explanation/ demonstration: Questioning Individuals	Teacher: We're going through Cluan – any Japanese cars out there – anyone selling Japanese cars in Inis? (*laughter)* 8 kilometres so that's the kilometres so there 8 to Bunloch, who can tell me, hands up, how many kilometres would be on the clock when you're passing Bunloch?
16:04	Sean answers teacher's question without being asked.	*Sean:* 40
16:05	Teacher responds.	*Teacher:* Shh I didn't ask you. *Students laugh*
16:07	Teacher asks Andrew a question.	*Teacher:* 5 – there's 25 here. Hands up – that's 25 – 5 times more than that *(teacher pointing to 8km)*. Come on! You should know it. Andrew – you're the first hand up?

16:17	Andrew answers question.	*Andrew:* 40
16:20		*Teacher:* 40, good man, 40. Now you're passing through this place here again, this place in the centre. Who can tell me this time, I want to see more hands up this time, how many kilometres is it when you look at your clock there. Come on 8, 12,13 hands yes, this time what is it?
16:45	Maria volunteers answer.	*Maria:* 24
16:47		*Teacher:* 24 yes. How did you get it?
16.48		*Maria:* Add 40 and 8 and then half it: 
16:50	Explanation/ demonstration: teacher centred.	*Teacher:* That's right – so it's 24 – OK. So you added – that was X_1 and X_2 right – so who gave me that one at the beginning that told me to add 25 and 5 is 30 and the half of that is 15? So you added your $X_1$and X_2 and divided by two here. What would you call that one – Y_1 (08) and that's Y_2 (40) – you add up the 2 of them and divide it by 2 and that is you're mid point-formula. Add your two Xs and divide by two. Add your two ys and divide by two so <u>MP</u> right underneath – where you have the midpoint here. You don't need this but if you wanted it to help you, take it down at the side. Your midpoint (MP) is equal to, what did we say again? X_1 plus X_2 and we divided by two, comma, and we had Y_1 plus Y_2 and we divided that by two. And if we go back to our two points that I asked you in the beginning – for example, a is minus one minus two (–1,-2), b what did we say, plus three plus two (3, 2): (–1, –1) (3, 2)

Over head of those, we just write down X_1 Y_1 X_2 Y_2 and write down the mid-point is equal to formula X_1 plus X_2 over 2, Y_1 plus Y_2 over 2:
(X_1 Y_1) (X_2 Y_2)
(–1, –1) (3, 2)

$$MP = \left(\frac{x_1 + x_2}{2}\right), \left(\frac{y_1 + y_2}{2}\right)$$

Notes

[1] The clock refers to the milometer on a car and is used as an illustrative example by the teacher. See Appendix 5 for a more detailed explanation.

[2] An example of real life application questions from our study involves a situation where the teacher asks the students for information, their shoe size for example, in order to demonstrate mean and mode. Checking understanding includes the teacher checking student progress during student practice, as well as asking the class if they understand the method or procedure.

[3] Freire (1972) claimed that mainstream education was suffering from narration sickness. Students went to school to receive bundles of knowledge from the teachers that they then banked in their memories and reproduced, generally uncritically, on examination days. The 'dividend' the students received on the time and effort they invested in banking the knowledge was the educational certificate or credential awarded.

[4]Bernstein (1977) suggests that strong classification exists when the content of each subject is strongly insulated from that of others and when there is a low level of subject integration. Classification therefore refers to the *boundaries* between subjects rather than the content of the subject matter itself. Framing refers 'to the form of the context in which knowledge is transmitted and received. Frame refers to the specific pedagogical relationship of teacher and taught' (ibid, p. 88). It refers to the degree of control the teacher and student possess over the selection, organisation, pacing and timing of the knowledge transmitted. Strong framing exists when neither the student nor the teacher have much control over what is taught and how it is taught.