Teaching and learning across the curriculum: observations from mathematics, humanities and science classrooms

This report presents a summary of observations made by the consultant in 37 classrooms in EMI schools as part of the *Language Courses for Specific Subjects* (LCfSS) project. The LCfSS project had two components: workshops[1] between October and December 2006 and observation of one lesson of most of those participating teachers. Each teacher was requested to forward a lesson program indicating how they would be implementing what they had learned from the workshops. Following each lesson observation, the consultant and teacher discussed the lesson. What I, as consultant, present in this report summarises the points of discussion with all of the teachers and I have attempted to organise them according to some generalised aspect, such as the amount and kind of talk that happens in classrooms or syllabus load and class size.

What I would like to stress is that the overwhelming majority of the teachers were interested in exploring more about how students learn in their subjects and about ways for improving their teaching so that their students are learning more successfully. These teachers were willing to hear and take on advice and this report is a continuation of the discussions I had with them. My hope is that these teachers read this report and consolidate their understanding while other teachers who read this report can learn from their peers.

Who gets to talk in class?

This aspect of teaching and learning varied greatly from class to class and appeared to be crucial to the success of the classroom.

The lessons in which students' behaviour indicated that they were not learning to the level expected were those in which the teacher spoke for almost the entire lesson. Some of the students in those classrooms typically disregarded what the teacher was talking about and did their own work, exhibited boredom by sleeping, talked amongst themselves about things other than the content of the lesson or were distracted in some way or other. The suggestion could be that the students lacked motivation but that was not necessarily so. In one school, the same students were observed in more than one lesson and their engagement in each lesson was a direct result of the teacher's way of teaching. When the teacher's organisation of the tasks and their interaction with the students promoted interactivity, then the students were positive, interested, respectful and, most importantly, they were learning effectively. When the teacher lectured to the students, which forced them to listen passively for a full lesson, it was difficult to ascertain what kind of learning was happening. It appeared that some of the students had already determined that they would not be learning in that classroom and so would need to learn by reading the textbook, asking their friends or taking extra tuition outside of school.

Encouraging students to talk

One of the ongoing "wishes" made by teachers is that they wished their students would contribute to discussion in the classroom. My response to this is to analyse the kind of classroom interactions I have observed. I must say that I have seen students who are eager to contribute to class discussions. Most of these students are in Form 1 but some are in Form 6 so it is not necessarily more difficult to do in the upper forms. It seems to me that the Form 1 students have come to secondary school eager to participate in their schooling. Even with the level of English they have, I have observed that they are still willing to engage actively in classroom talk. Is there any similarity between these Form 1 students and the Form 6 students who were also eager to participate? The answer to that seems to lie at the feet of the teachers. The way the teachers in both forms spoke to the students was similar:

- it was open and welcoming so the students could contribute

[1] Details about the workshops can be found in Appendix 1.

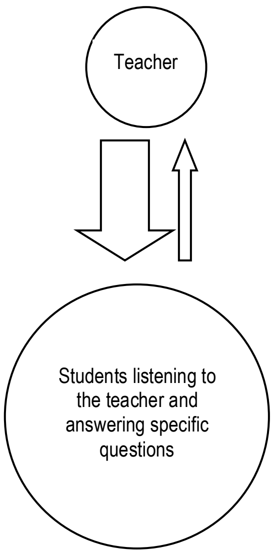
- it was supportive in the sense that the instructions were clear and the students were prepared well for the activities
- it was important to the students because they could see they were learning
- it was clear to everyone that the teacher and students were engaged in activities that pushed and challenged their understanding to higher levels.

Sample analysis of classroom interaction in a Form 6 Physics class

The students had to design an experiment about three aspects of physics they had been learning.

Step 1

At the start of the lesson, the teacher revises the content the students need for their activities.

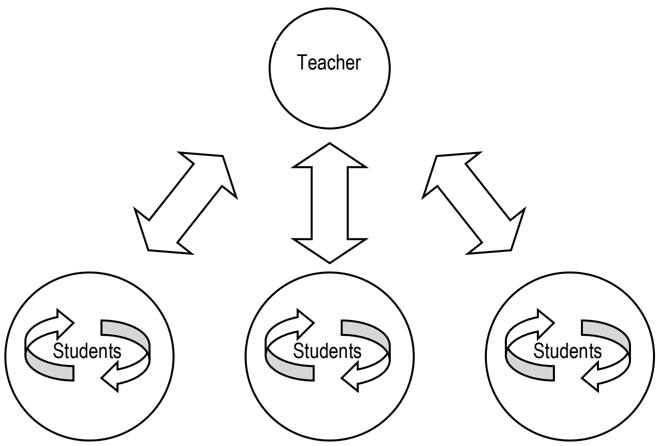


The teacher is in control of the transmission of information and does most of the talking. However, the questions asked by the teacher are expected to be answered in an extended way by the students. The teacher continues to elaborate and extend but also asks for clarification, explanation and reasoning. In this way, the students are provided with a lot of information by the teacher but are also involved by the teacher. This means that when it comes for the students to do the task the teacher sets, they are clear about the content of the task and the process of the task.

Another important aspect of the way the teacher supported the students' learning was the way he 'unpacked' technical terms, eg by talking about inducing or creating or producing an emf after he introduced the abstract term, induction. His questions to the students then allowed them to use 'induce' before they used 'induction'. This interplay between abstract noun and more concrete verb and back to abstract noun is effective in developing the concept, an ability to use it to discuss solutions to problems and also an ability to read and write more complex and technical texts.

Step 2

The students have been instructed to work in groups to design an experiment. One group is to work with impurities and the melting point of ice, another is to design an experiment on the behaviour of light and the third is to work with the inducement of electromagnetic force.



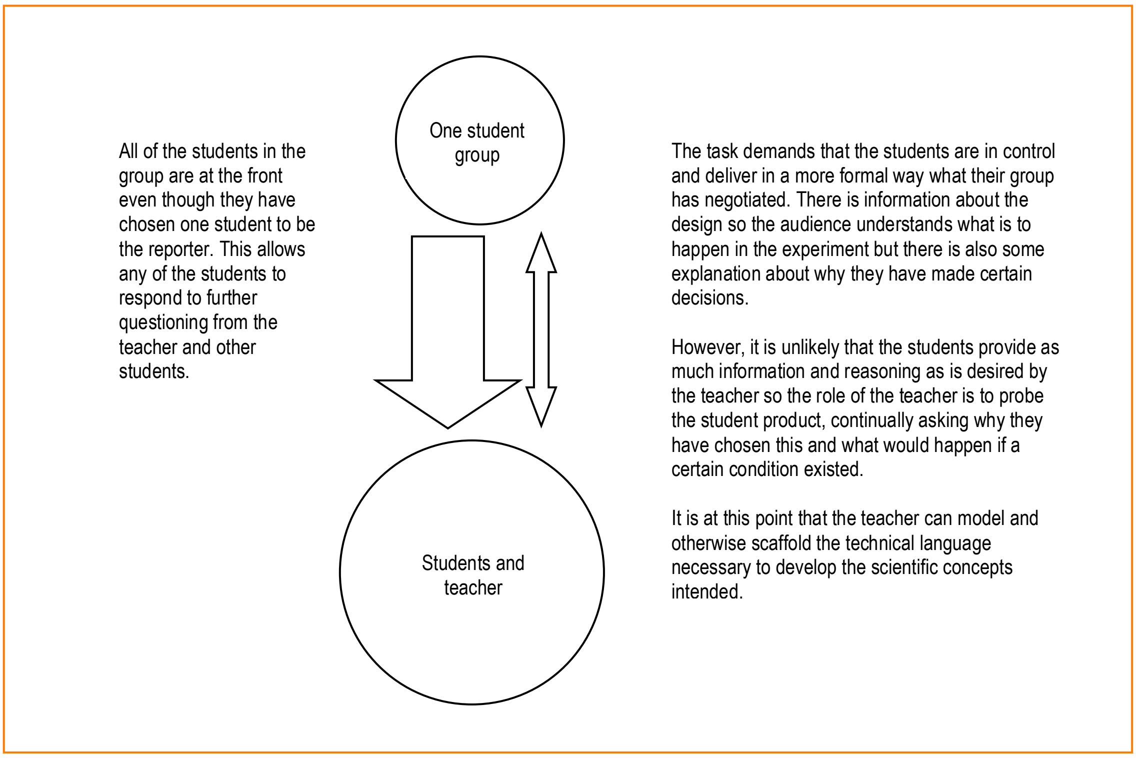
Students in groups of about 6

The role of the teacher has shifted from the controller of the input to the "knowledgeable" contributor to the group discussions. The task demands that the students negotiate their group's design, using the language needed for information-giving, reasoning, explanation and clarification.

Group work, such as this, allows students to be involved in negotiating, using whatever level of English they have since working face-to-face with their peers is less pressurised than standing up in front of the class as an individual. It allows them to explore their understandings of the topic in a more interactive way.

Step 3

The students come to the front of the class in their groups and report to the class on their design for the experiment.



The fact that each group presents on a different experiment means that the other students listen to the presentation. If the students were required to take notes on what the students present, in order to complete a task, then it would mean that they would listen even more attentively and be more likely to ask questions of their peers. If each group were to present on the same experiment, it is more probable that they will not listen because the task does not require it.

Working with technical vocabulary

I have written at length about how to develop vocabulary in another article in this publication (refer to *Observations on vocabulary development in EMI schools*) so here I would like to focus on the timing of introducing technical terms. Many times, technical terms were introduced early and time and energy were spent on trying to explain to students what the terms meant. At these times, it seemed that the technical terms were introduced too soon for the students. At other times, the students showed that they had understood the more common terms and yet the teacher didn't start using the technical terms until much later in the lesson and it seemed that it was unnecessarily late. My suggestion is that if students have shown that they understand the common terms then it is at that stage that they are primed for receiving the technical term and that ongoing use of the technical term in spoken and written form will consolidate its understanding. For example, Form 1 students were working closely with the teacher on describing how heating gives energy to the particles of the matter, which move faster and further apart and hence the matter gets bigger. All the students understood what it meant to 'get bigger'. At this stage, they were primed for being told by the teacher that scientists prefer to use the term 'expand' instead of 'get bigger'. After this activity, when the students returned to their benches and worked on writing the explanation for this phenomenon, they would have been able to use the terms 'expand' and 'expansion' and by doing this, they would have consolidated their learning of the technical term.

Syllabus load and class size

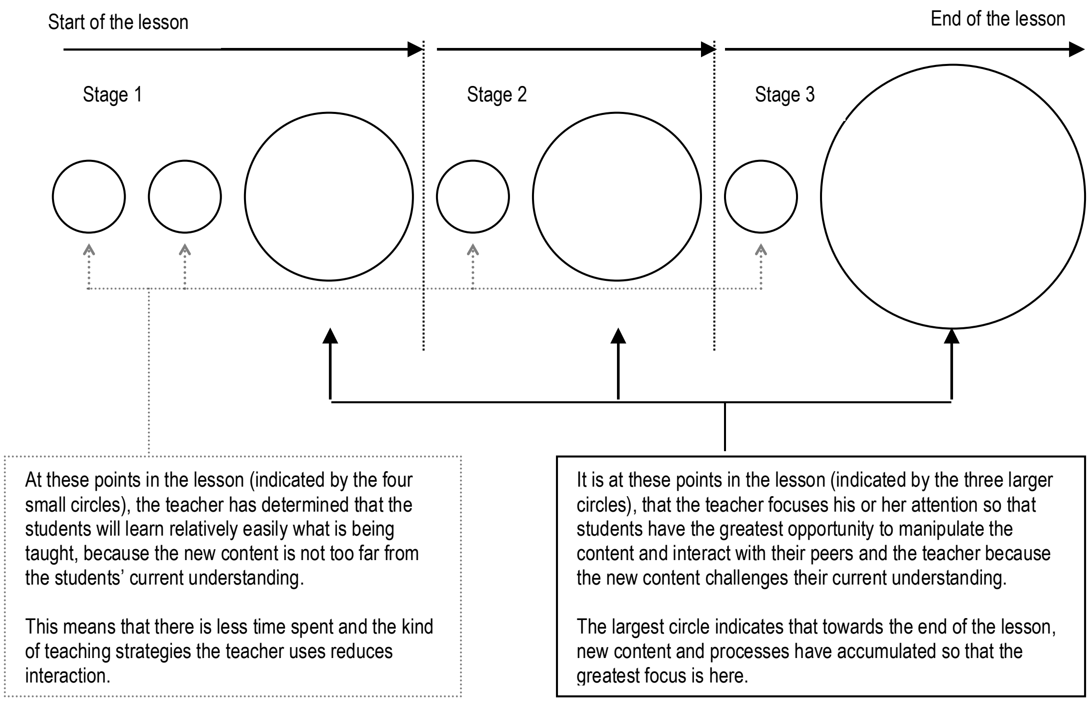
The argument has been put by many teachers, and this period of lesson observation was no exception, that the large classes and, especially, the tight, content-heavy syllabuses pressure them to teach in certain ways, such as to lecture. They suggest that they would have more interactive classrooms with positively engaged learners if only they had less content to cover and smaller classes. It is not at all certain that that is true. From my observations, better teaching did not happen simply because classes had fewer students—some of the Form 6 classes were examples of this. Conversely, some very interactive teaching was possible in large classes and some of the lower forms were examples of this. This is not to say that even better learning could not have occurred in the lower forms if the class sizes were smaller. My point is that while the debate about exam-oriented, content-heavy syllabuses and class sizes continues, there are things still to be done in classrooms to improve learning. Some methods I have mentioned above and the remainder of this report will present others.

Ways of working with large classes and content-heavy syllabuses

There are ways of working in a classroom even when a lot of information needs to be covered. Several things need to be considered before the teacher even enters the classroom. One is to analyse the content to be taught and think about how it is organised (its sequence and the links between each part). In this way, the content can be broken up into components and the teacher can decide to spend more time on different parts according to their significance and what the students have learned before.

It appeared to me that teachers often spent a lot of time on aspects that the students learned quite easily but less time on the more complicated aspects. It also made me think about the kind of teaching that happened with each aspect. It is reasonable to assume that a more teacher-directed teaching could be used for those aspects that are either less complex or closer to their current understanding and a much more scaffolded, interactive approach be used for the significant, more challenging parts—see one possible way of viewing this.

Sample organisation and degree of teacher-control of a lesson



Another consideration is that the students ought to be active in their learning. The forms of activity are many and varied but I would like to focus here on one example of manipulating the knowledge, such as reorganising packages of information in a visual format so that the connections between the various component parts are made clear and are expanded on. A lot of the content in each subject is organised according to taxonomies that are made up of different kinds of phenomena or the various components of the phenomena. While the class is being taught the content, the students could be involved in constructing the taxonomies as they go along, adding features, similarities and contrasts alongside the various elements of the taxonomies. In this way, subjects with a large number of technical terms, such as biology and economics, would then have the students actively using the terms as they are being taught. The teacher's questions then are not about the features of the information presented but about explanations and further probing of the information so that the students are made to reason and to think critically. It is in the active interrogation of information that real learning happens. And it is the teacher's role to be the one who pushes the students to think in those ways through the kind of questioning and explaining that occurs.

Moving from the specific to the generalised or the generalised to the specific?

Another aspect of teaching and learning observed was whether the teacher chose to start from a generalised concept, such as a theorem in mathematics, and move to specific applications of the theorem or whether the teacher chose to start from specific examples and then move to the generalised. It appeared that most teachers chose the former—moving from the generalised to the specific. I would question the appropriateness of that, especially when the theoreticians who conceptualised the theorem themselves went from observing specific examples of a phenomenon in order to formulate the theorem.

I observed classes where students struggled to comprehend the abstract theorem only to then start to understand when the examples were considered. My question is whether it would not have been more reasonable and logical to move from what the students already understood and could observe and get them to find or at least recognise the patterns and from there generalise to the theorem. This would be a much more active involvement in the learning.

Working with the three ways of making meaning in mathematics

In the LCfSS workshops for mathematics, the teachers were introduced to the notion that there are three main ways of making meaning in mathematics: through language (verbal), through such things as graphs and diagrams (visual), and through equations (symbolic). As students learn mathematics, it seems that the mathematical concepts become increasingly abstract so that by the time they get to the upper forms, it is as if the learning is at a very abstract level.

What kind of teaching can occur at that level? It appears that the typical way is to work through the theorem and then ask the students to either prove the theorem or give certain values with which to test the theorem. Although I have questioned the effectiveness of this form of teaching, which more resembles lecturing, I have observed that it can be successful if the teacher is absolutely clear in his or her use of the symbolic, verbal and visual. The slightly extra time spent in writing up clear equations and visuals controls how much and what kind of language is used by the teacher alongside the equations and visuals. I observed this in a lesson on the theory of limits and it was the teacher's ability to clearly connect the symbolic, verbal and visual that enabled him to maintain engagement with the students. In other words, it is possible, if these various elements are done well, to overcome the lack of active participation by the students in that part of the lesson.

Scaffolding in mathematics classrooms

A pedagogical practice discussed in the LCfSS workshops for mathematics (science and humanities workshops, too) was what is generally discussed as a teaching-learning cycle, where:

- the first stage is to set the context of the learning, stimulate the interest of the learner and activate their prior learning
- the next stage would be providing a model for how to do what is required, ie "This is what I would like it to look like and this is how you do it

- the third stage would be for the teacher and students to jointly attempt doing the task, with the teacher showing, guiding, advising, probing, extending and questioning
- the final stage would have the students largely independently attempting the task with the teacher as the overseer, reminding and clarifying but not doing.

My observations indicated that the majority of the mathematics classrooms do the first, second and fourth stages but omit the third stage. The significance of this stage is that it is here that teachers can illustrate the thinking processes and decision-making that go into successfully completing the task. They can guide the students' thinking through the kinds of probing they do, the kinds of questions and extra information they provide. It is this stage that also allows the students to actively use the technical language that is necessary to develop the concepts to be learned.

Of course, these comments are not relevant only to mathematics as indicated by including the teaching-learning cycle in the science and humanities workshops, as well.

John Polias

Project Consultant