

Teaching Science through English: Integrating Subject and Language

John Clegg

School of Education
University of Nottingham, UK

John Clegg is a freelance education consultant and special lecturer in the School of Education, University of Nottingham specializing in the following areas: ESL and EAL in the UK, English-medium education in bilingual schools in Europe and teacher education for both primary and secondary teachers.

He has been professionally involved with many educational projects such as the English Language Education Trust, Durban South Africa, the Imfundo Initiative, Department for International Development, London, the 'Language for Learning' and PETRA projects in South Africa, the Molteno Project in Namibia, the ODA Teacher-Education Project in Zimbabwe.

He has published a number of articles and presented numerous papers as keynote speaker and presenter. He has five publications to his credit, among them *Real Time Teacher's Book* and *Advanced Reading Skills*.

He obtained a BA (Hons) in Modern Languages from the University of Oxford and his career in education has spanned more than 30 years.

ABSTRACT

Subject teachers who teach through a second language are often confident about their subject, but not about the second language. They may feel that they are not quite fluent enough in it, that it is difficult to get learners to understand their subject well enough, and that teaching in the second language slows down their teaching and makes it difficult to cover the curriculum.

It is however, possible to teach subjects in a second language in a way which helps learners to learn both subject-knowledge and the second language, often simultaneously. To teach in this way, teachers use specific types of learning task, specific ways of presenting concepts, specific visuals and forms of classroom interaction. They also encourage their learners to use their mother-tongue at particular points in the lesson and to develop some key learning skills to help themselves with the difficult business of learning in a second language. Most of these teaching strategies are not difficult for a subject teacher to learn.

This presentation describes appropriate pedagogy for teaching science through English as a second language and illustrates this with practical examples from the English-medium science classroom.

I am going to talk about teaching subjects in a second language (L2) and in particular how subject teachers can support their learners in learning both the subject and the language they need in order to do this. I will be using examples from science, but what I say is relevant to teaching any subject. I'm also aware that there may not be much I can tell you about working in a second language. You have already accumulated a good deal of expertise in it. What I can perhaps do is to talk about how I have seen other English-medium teachers in other countries do it.

I'd like to start by discussing who should provide learners with language support in English-medium subject teaching. Then I'll move on to look at pedagogy for the language-supportive teaching of science. After that I'll mention briefly the matters of school policy and the status of children's first language (L1). Finally I'll discuss support for teachers and the role of English language teachers.

1. Who should teach learners language in L2-medium subject-teaching?

Getting an education through a second language can be difficult when the learner does not speak the language fluently enough. It is not always difficult, and many children all over the world do it. But it is usually more difficult than learning through the mother-tongue. You have to do two things at once: you have to learn subject-matter knowledge and you have to learn the language ability which is the medium for acquiring that knowledge; and you have to do these more or less at the same time. Under normal circumstances learners may not have enough mental processing capacity for this: we are asking them to do too many things at once. To do it, learners need help; and if they don't get that help, their learning in the L2 can be slow and inefficient. In order to give this help, subject-teachers have to teach their subject in a particular way, which combines support for learning subject-matter concepts with support for learning the second language. The main purpose of my presentation today is to describe this special kind of pedagogy.

The teachers who should use this particular approach to teaching are the teachers of the subjects which the learners are learning through the L2. Many people – especially subject teachers themselves – think that subject-teachers can teach in a L2 by using the same pedagogy that they use when teaching in their L1. Perhaps that would be the case if their learners were fairly fluent in the L2; but if they are not fluent, this different specialist pedagogy is required.

Many might also say that it is the language-teacher's job to teach the learners enough language ability to make them fluent enough in the L2 to use it as a medium for learning. It may indeed be useful to teach the L2 intensively before L2-medium subject teaching

starts. Many projects in education through a L2 rely on an intensive pre-project language programme. But this intensive programme may need to be lengthy – perhaps even a year depending on the age and L2-experience of the learners. And it would need at least partly to be orientated towards the language of the subjects which the learners were going to learn in their L2. But many L2-medium programmes require learners to start learning the subject through the L2 before they are fluent.

Perhaps the intensive language programme could run in parallel to the L2-medium programme. A programme like this definitely has its uses. But the learners would still be learning the subject from the beginning through the L2 in which they are not fluent. In addition, parallel language support teaching in L2-medium subject programmes has been found in some contexts to be less than useful. In the education of minority language children in the industrialised North, for example (the UK, USA Australia) parallel language support has been found wanting and a good deal of the burden of language development has been shifted into the mainstream subject classroom, to be carried there to a considerable extent by the subject teacher. This is because the language ability which the learners gain in separate language support classes does not transfer easily to learning subjects. It is often not orientated to the cognitive and linguistic requirements of learning subjects. And in addition, **good** subject-teaching through the medium of an L2 often has a higher potential to develop subject-learning **and** language-learning than parallel language support provision. One reason for this is that learners learn language best at the point of need; and the point of need is in the subject classroom. However, I emphasise 'good': poor subject teaching through the L2 may not have this language-support potential. In the end, I think we all know that it isn't possible to separate subject-matter knowledge from the language which we use to express it and to learn it. It won't work. Language teachers can help. But the subject teachers have to do the main work.

Subject teachers often don't want to hear that if they teach through a L2, they will need to change their practice. They are busy people; working in the L2 themselves may be difficult enough, quite apart from an increased work burden which learning new teaching methods may imply. Similarly, education authorities may not want to hear that teaching in a L2 is different from teaching in the L1. They may feel that teaching a subject in a L2 is the same as teaching in a L1, except that the language is different. They may not want to pay for the training which subject teachers will need in order to acquire new teaching skills. Indeed they may not know that teaching in a L2 is different from teaching in a L1. Many bilingual programmes across the world don't work well because the education authority doesn't understand the professional skills which subject teachers need to have in order to staff the project, and fails to provide the teachers with the necessary support. Training teachers to work in a L2 is a key organisational issue and I will come back to it later.

I don't want to say any more about who should provide language support: there is much more to be said, but it isn't my purpose here. Everything points to the fact that if we want to teach learners a subject in a L2, when they are less than fluent in that language, subject teachers often have to shoulder much of the burden of those learners' language development. And to do that, they have to use a particular pedagogy. So let me now turn to describing the main features of an appropriate pedagogy for education in a second language.

2. A specific pedagogy for L2-medium subject teaching

In order to describe these features, the first thing we have to do to establish what the experience of learning in a L2 is like and in particular in what way this experience is different from learning in a L1: what language skills does the lesson require the learners to possess in order to learn in the L2? These are the so-called language demands of the lesson and they are at the heart of teaching and learning in a L2.

2.1 The language demands of school learning

We can describe language by using the following categories:

- **Language skills:** the classical four skills of listening, speaking, reading and writing. Science often requires learners to listen to teacher-presentations of science concepts, talk about what an experiment might require them to do, read a science textbook or write a description of an experiment
- **Discourse:** the way texts are organised. Learners will have to see this organisation in textbooks, or make it apparent in their own writing. Discourse is often signalled by connectors: in describing a scientific experiment, for example, learners will need to signal events happening in sequence, by using connectors like *first, then next, finally*.
- **Function:** the communicative purpose of using language. Science requires learners to engage in particular thinking processes, such as hypothesising, predicting, showing cause and effect, drawing conclusions. To signal this they will need to make sentences using *might* or *will* and phrases such as: *for this reason, this is because, this shows...*
- **Grammar:** how to string words together in the sentence
- **Vocabulary:** vocabulary specific to science, and general cross-curricular academic vocabulary as shown in figure 1.
- **Sounds/spellings**

Learners learning a subject in a L2 will find some of these language demands easy and some difficult, depending on how good his/her English language ability is, how cognitively complex the learning tasks are and how familiar the subject concepts are. Most learners who are still developing their L2 ability will need some language support.

Figure 1: general academic vocabulary

a) Amount/number

A lot of A large amount of Very much A considerable/large amount of	rice
Little A little Very little Hardly any	
Many Very many A number of A considerable/large number of	people
A few Few Very few Hardly any	

b) Constancy

stay remain	the same constant steady stable
Fluctuate	
is/are	fluctuating irregular inconstant unsteady unstable

2.2 Sources of language support

The next question is: what sources of support can the subject teacher use? I will list 10.

- Use tasks which provide language and learning support as well as developing subject-matter knowledge
- Use a lot of visuals (pictures, diagrams, graphs etc)
- Teach some language
- Talk in a natural, interactive, comprehensible way
- Signal the organisation of your talk clearly and support understanding with all available means
- Vary the form of interaction (e.g. whole-class, small-group, teacher-student 1:1, individual work) according to fitness for purpose
- Teach key learning strategies
- Agree ground-rules for the use of students' L1
- Ensure the purpose of tasks is clear and the sequence of tasks is orderly
- Establish a warm but disciplined classroom atmosphere

Let's look at them briefly one by one.

a) Tasks

Teachers can use a range of classroom tasks whose purpose is to provide **language and learning support** as well as developing subject-matter knowledge. Some of these may be unfamiliar to the subject teacher; some may be difficult for a subject teacher to make. If that's the case, don't use them. But some are easy to use and make the teacher's life in the English-medium classroom easier. These task-types are listed in figure 2.

b) Visuals

Teachers can also use a lot of visuals: e.g. pictures, diagrams, graphs etc. Science is particularly appropriate for learning in a second language, because it involves so many visuals as well as so many things to touch and to do. In particular, what are known as 'key visuals' for showing the structure of information in a text, are very useful. This makes sense: visuals help learners understand complex information without making heavy demands on their L2 ability.

c) Language

Teachers can teach their learners some language – vocabulary, for example. As far as subject-specific vocabulary is concerned, they will do this as a matter of course. But we shouldn't forget that there are other parts of language which subject teachers expect their learners to be able to use. I mentioned earlier the language of general concepts in school learning (Figure 1). A list of these would be useful to a science teacher.

Figure 2: Task types for language and learning support

- | | |
|---|---|
| <p>1. Fill gaps</p> <ul style="list-style-type: none"> • Fill short gaps • Fill long gaps <p>2. Words/phrases</p> <ul style="list-style-type: none"> • Sentence starters • Phrase bank • Connector bank • Word bank <p>3. Match</p> <ul style="list-style-type: none"> • Match word with description • Match word with definition • Match picture with sentence
 • Match word with sentence • Match 'heads' and 'tails' • Match paragraph with heading <p>4. Fill in a chart</p> <ul style="list-style-type: none"> • Tree-diagram • Venn diagram • Matrix • Columns • Flow-chart <p>5. Pictures/diagrams/maps</p> <ul style="list-style-type: none"> • Make • Label <p>6. Notes</p> <ul style="list-style-type: none"> • Linear • Spidergram | <p>7. Substitution tabl</p> <ul style="list-style-type: none"> • Simple • Complex <p>8. Sequence</p> <ul style="list-style-type: none"> • pictures • sentences • words in sentence <p>9. Writing frame</p> <ul style="list-style-type: none"> • Headings • Sentence starters • Other items <p>10. Sort cards</p> <ul style="list-style-type: none"> • Classify • Sequence • Match <p>11. Texts</p> <ul style="list-style-type: none"> • Create • Complete • Mark (e.g.: underline, box, colour-code, etc) <p>12. Line</p> <ul style="list-style-type: none"> • Timeline • Attitude scale • Other relations <p>13. Activity organisers</p> <ul style="list-style-type: none"> • KWL grid • Research grid |
|---|---|

What about, in addition, the phrases which we use to engage in key thinking processes, which I also mentioned above. Do the learners know how to express these thinking processes in the L2? If they don't, they can't easily engage in them – except of course in

their L1. So it might be useful for a subject teacher to have a phrase-book of all the main thinking processes which we ask our learners to use and the main phrases which are used in the L2 to express them. In Figure 3, you can see examples of two key thinking processes which might be used in science, together with relevant phrases that teachers and learners might need to express them. Language teachers can of course also teach these phrases, but learners learn them better at the point of need. And it's not difficult for a subject teacher to put 2 or 3 phrases on the board at the key moment. In addition, subject teachers might find it useful to have a list of connectors (such as the terms mentioned earlier for time sequence, cause and effect etc): terms they can give their learners to help them organise ideas in a text.

And if you feel uneasy about whether you know enough about language to do this, ask your English colleague to help you and cover some of this ground in the English lesson.

d) Teacher-talk

Interactivity

- Questions: use different question types according to the learner (e.g. use a short answer question for learners who find English more difficult and a longer-answer question for learners who find it easier. Use a higher-order question for learners who can deal with cognitively more difficult concepts and a lower-order question for learners who can deal with cognitively simpler ones)
- Pace and loudness: use normal pace and normal loudness
- Interactivity: use learners' names
- Use body language, gesture, eye contact

Organisation

The way teachers talk makes learning easier or more difficult. What are some of the ways in which you can use talk to make it easier to understand? I'll mention a few.

- Beginnings and endings: signal clearly the beginning and endings of lessons and sections
- Numbers: signal clearly how many points you are going to make and number them as you talk
- Prospect and summary: signal clearly what you are going to do in each lesson and each lesson section, and signal clearly what you have done at the end of each lesson and each lesson section
- Cognitive moves, e.g. illustration, explanation, contrast, time sequence, etc: signal these clearly by using common connectors

Figure 3: Language for thinking

1. Defining

What is a...?

Give me definition of a...

How would you define a...?

Who can define/give me a definition of...?
 Can anyone give me a definition of...?
 What do we call this?
 What is the name/(technical) term for this?

(A)	is a	(generic term) place person thing concept entity device instrument tool etc	where who which that
-----	-------	------	--	-------------------------------	-------

... is called ...
 The term/name for this is...
 We call this...

2. Classifying

How would you classify...?
 How many kinds of ...are there?
 Who can classify...?

There are	three	kinds types forms classes categories	of	
.....	fall can be	divided classified	into	three	kinds types classes categories

We/you/one can classify ... according to ...criteria
 This class has...characteristics/features

e) Forms of interaction

Use a range of forms of interaction according to their fitness form purpose. Use teacher-fronted work to present new ideas, or summarise etc. Use pair- and small-group work to give the learners a chance of investigating ideas – especially if it is possible for them to do experiments themselves – and getting their understanding of ideas clear (but don't necessarily expect them to use English – I'll come back to that). Use 1-to-1 work to talk to individual learners and individual work for quiet consolidation of new concepts.

f) Learning strategies

Teach the learners some learning strategies. Learning in a second language is not easy. To do it successfully, learners need to know that there are some strategies they can use to help themselves. For example, how to learn and remember vocabulary, how to use diagrams, how to follow teacher-presentations, how to work efficiently in groups, how to plan and write the description of an experiment, how to read efficiently, etc. If your learners know these strategies and can use them without being prompted, they can help not only themselves but you as well – by taking some of the responsibility for supporting their learning off your shoulders. Again, if you feel you don't know how to teach these strategies, ask your English language colleague to do it in his own lessons. Or ask your mother-tongue teacher to do it in her lessons: these strategies are useful for school learning in any language.

g) The bilingual classroom

Acknowledge the bilingual classroom: both you and your learners will often need to switch into your first language for some purposes. Acknowledge that this can be useful and sometimes essential. For example (to return to 2.2 (e) above), learners getting a concept clear in their minds for the first time will often need to do this in their L1; it may not be possible to do this in-depth work in English. But don't do it too much and agree ground-rules with your class for when it is OK and not OK.

h) Task purpose and sequence

Make sure that both you and the learners know why they are doing the tasks you give them and in what order. Many of us may be a bit chaotic about our lesson structure. You can get away with that if you are working in the children's mother-tongue, but not if you are working in a L2: it confuses them too much.

i) Atmosphere

Be encouraging, warm and responsive and maintain discipline. Again, if you don't do these things when teaching in the mother-tongue, your learners may still learn. But if are too cold, strict and impersonal when working in a L2, it will make learning extra difficult.

3. Institutional matters

I have been talking up to now about classroom practice. But a school which starts to teach subjects through a L2 needs also think about policy. It is difficult for a school to achieve high standards in English-medium teaching if it does not take some steps on an institutional basis.

3.1 School policy

Some of the things which will help English-medium education work are matters of school policy. These include:

- Assessment: how will teachers assess learners working in a L2? It may not be easy. They will need to establish how to do this and to agree to use the same methods across the school
- Entry: will the school accept any child into an English-medium classroom or just selected groups? And how will this selection take place?
- Training: will the teachers working in English need training? Can they find this training? And can they be released?
- Parents: will they agree that their children should learn some subjects in English? Can they be recruited to help in the process?
- Resources: what resources will be needed by teachers working in English – especially textbooks? And where will they get them from?
- Support from the school senior management: does the management agree with English-medium education or have they been required by a higher authority to offer it? Can they, in other words, give this initiative the support which it will need?
- Evaluation: how will the initiative be monitored? Who will do this?

To establish a school-wide policy which can answer these questions requires support from the school management and also a steering group of some kind which can make, maintain and monitor policy. Schools which are used to policy development of this kind will achieve more than schools which are not.

3.2 The status of the mother-tongue

Finally, I should say a word about the effect of English-medium education on the status of the mother-tongue. Teaching in English often means teaching in a language of power. A language of power can easily come to be seen as more statusful than a child's mother-tongue. And so education in the mother-tongue is sometimes seen as less valuable. When this happens, there is a potential risk to the mother-tongue. This is

particularly the case if teaching in a second language becomes associated with schools in rich areas. This can also easily happen. Learning in a second language is often easier for learners from well-educated middle-class backgrounds and more difficult for learners from less well-educated backgrounds. It isn't of course that these children don't have the ability to learn in a second language. It's simply that, just as education generally tends to disadvantage children from poorer backgrounds, education through a second language can do this even more. And thus education in a language of power can easily come to divide rich and poor. We shouldn't try to hide this problem. It is real, and all stakeholders in such a project – parents, children, teachers, trainers, education authorities – need to be aware of these risks and to guard against them.

4. Support for Teachers

I've been talking mainly about learners learning through English as a second language and how we can support them. Whereas I'm sure what teachers would like to hear is how we can support *them*. Perhaps you think that what I've been saying makes your lives more difficult.

It may sound like that. But I should say at this point that subject teachers don't have to use *all* these sources of support I've mentioned. They will have good reasons for not using some of them – those, for instance, which are unfamiliar, or which are difficult to use, or which require a lot of preparation time, or which the teacher may find simply uninteresting. In addition, many teachers will routinely do some of these things already; you just have to exaggerate them in teaching through a L2. And some of them are easy to do. And to a certain extent this list is a menu: you can choose from it. But equally if a subject teacher uses none of these sources, her learners will find her lessons difficult and she will find her teaching an uphill struggle.

Let me now turn to the matter of teacher-support. Teachers teaching their subject through English often find it difficult. If they do, what might be the problem? Let me list a few.

- They may feel their English is not adequate
- They may feel that they need to learn new teaching strategies
- They may feel they are too busy with routine teaching to learn new strategies
- They may find they haven't got the right teaching materials
- They may not have volunteered for this project
- Their students may not have volunteered for it
- They may feel unsupported by authority – either by the school management or by an education authority
- They may feel the authorities want results too quickly.

I'm sure there are many more. But let me discuss some of these very briefly.

4.1 Teachers' English language ability

Firstly, it is common for teachers to feel that their English is not good enough. And they may need extra language development, in which case classes need to be made available and schools have to be supported in releasing them. It is possible, to a degree, to specify the language needs of English-medium subject teachers and thus to make the job of learning English more of a special-purpose enterprise. It's also possible to help oneself to learn the English one needs for subject-teaching. Subject teachers should also be aware that they can use their learners' mother-tongue. I've talked briefly about that. It would be wrong to think that there is no room for the mother-tongue in class, either on the teacher's or the learners' part. But only under certain circumstances, which teacher and learners should agree.

4.2 New teaching strategies

I think I've said enough about these. Subject teachers will often need in-service training in new pedagogy. Secondary teachers may need it more than primary teachers. It doesn't have to be long and complex training: the pedagogical issues I have talked about today normally make sense to teachers. If they need it, but don't get it, that will make their professional lives harder. I will reiterate that education authorities often think that English language development is all a subject teacher needs. That's often not the case, especially if the learners are still developing their L2 skills. Authorities who think that teaching subjects in a L2 is like teaching them in a L1 but in a different language, may well be compromising their L2-medium project.

I should add here that it's important to have people who can give this support. There must be, somewhere in the education system, people with expertise in teaching and learning in a L2. They may be in the universities, or the teacher-education community, or – very often – in the schools themselves. It is common for this expertise not to exist in the system in any easily findable way. This kind of pedagogy may be fairly new. It can also happen that authorities turn to the wrong people. In my experience, for example, it's common for authorities to look to the universities when university people think they know about it, but actually don't. That can harm a programme. In England, for example, it has in the past been very difficult to find expertise anywhere in higher education in teaching subjects in multilingual secondary schools I've also had the experience in other countries that the best potential trainers are actually in the schools doing good work in their classrooms. But they can't be used as trainers because the teacher-education system doesn't permit trainers to rise up the system from the schools, but only allows teacher-trainers, whether expert or not, to train teachers top-down. So, it's important to nurture good, practical expertise in English-medium education at an appropriate level in the system.

In the long run, of course, that expertise should be established and used in initial training. And even before an authority starts to introduce English-medium education into schools, it should be hard at work establishing training expertise in the teacher-education institutions, for the long term. And because this expertise is likely to be found in the schools themselves, there should be a mechanism which allows expert teachers to be trained as trainers.

4.3 Teaching materials

Teachers may find it very difficult to find appropriate materials. Teachers teaching subjects in English in European secondary schools, for instance, often spend hours looking for materials – often on the internet. Or they buy subject materials written for English native-speakers, which often turns out to be either cognitively or linguistically inappropriate. It's a big problem. If your education authority provides you with specially written materials, you are lucky.

4.4 Volunteering

Really, of course, both learners and teachers (and parents and schools) should volunteer for a new initiative like teaching in a L2. If they don't, and are required to take part in it, their motivation may be low and results may suffer. What else can I say?

4.5 English language teachers

Where does all this leave English language teachers? They are important. But they are not at the centre of things. In the end, subject teachers in both primary and secondary schools will carry the main burden of teaching in a L2. The pedagogy of teaching, for example, science is the pedagogy of language-supportive science teaching. It is not the pedagogy of conventional L1 science teaching with some help from the second language teacher.

So what should they do? Several things:

- They should do good English language teaching in the way they always have
- If they can, they should also teach the language of learning: not the language of subjects – subject teachers must do that. But the language of school learning – study skills in a second language. They may not be used to that; and here again they may need some training
- They can also offer development in the second language to their subject colleagues – outside teaching hours. I've seen this work well. But their colleagues would need to be willing and they themselves would need some kind of remuneration
- They can also offer pedagogical expertise to their colleagues – under the same conditions. But only of course if they possess that expertise. Some do: some of the teaching strategies we looked at earlier are familiar to language teachers.

Language teachers are important in L2-medium projects. They aren't central, but they can offer invaluable support.

4.6 Education authorities

Finally, a word about the responsibilities of education authorities. They need, I think, to do a few key things. Firstly, they do have to understand what education in a second language entails in terms of school policy and classroom practice – in other words the kinds of things which we have been talking about. And when they ask teachers to teach in a second language, they have to supply them with the support they need. I think also that it's useful to pilot English-medium teaching: you can learn so much from a pilot

scheme and you can avoid so many problems and save so much money later on. They should also ensure – in education systems in which inspection is influential – that inspectors know what good English-medium teaching looks like. And if they are finding it difficult to provide good teacher-education expertise, they should also be ready – as I have already mentioned – to use good teachers as trainers. One way of doing this is to employ them in a job-sharing capacity: they work part of the week as trainers and the other part as classroom teachers.

Lastly, authorities should keep their eye on the mother-tongue. English-medium education works best when learners have established good early cognitive and literacy skills in their first language. So good L1 learning in the early years helps good L2-medium learning later on. And in addition, as I mentioned earlier, L2-medium learning may not always be so good for the L1, especially if it becomes the province of the middle-classes.

I like education in a second language. At its best it can even more effective, in both subject and language terms, than learning in one's first language. But we have to get it right. Malaysia may soon be a country in which there are lots of English-medium science teachers who are indeed getting it right and to whom, in other parts of the world, we can look for expertise.

John Clegg jclegg@lineone.net

