Exploring and delivering bilingual teaching of electromagnetism classes

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ABSTRACT: Bilingual teaching of electromagnetism at a local university was undertaken in an attempt to adapt to the internationalisation of the world. The organisation of the teaching was changed, so as to allow for the delivery of bilingual teaching. Bilingual and non-bilingual classes were established, with students opting in to the bilingual teaching. An investigation of bilingual teaching was undertaken, including the selection of English teaching materials, a trial of the proportion of English used in the teaching and training in oral English in the process of conducting electrical experiments. This investigation identified ways to improve the effectiveness of bilingual education. This work should help to strengthen the aim of persistently and continuously pushing forward bilingual education.

INTRODUCTION

In today's world, where travel is common, it is advantageous for a professional to be proficient in foreign languages. Such professionals are in demand in China and also have the prospect of overseas employment. In 2001, the Ministry of Education in China issued a document, which stated: *Undergraduate education should allow for the using of English and other foreign languages to teach public courses or specialised courses* [1].

In 2005, the Ministry of Education issued a *Circular of a Number of Opinions on Further Strengthening Undergraduate Education to Improve the Quality of Teaching*. Again, in 2007, the Ministry issued a *Circular of a Number of Opinions on Further Deepening the Reform of Undergraduate Education for Improving the Quality of Teaching*. In the two documents, bilingual teaching was again promoted.

At present, bilingual education in elite schools is not new, but is only at the exploratory stage if it exists at all in local colleges and universities. Wang et al opine that *...those schools and professionals that cannot teach by using a foreign language directly, can arrange that part of the course be taught by using foreign language teaching material* [2]. In the Shaanxi Research and Development Center of X-ray Detection and Application of the School of Physics and Electrical Engineering at Weinan Normal University, Weinan, People's Republic of China, the teachers' foreign language proficiency has improved significantly in recent years as a result of language training for teachers. Some teaching departments have the basis for bilingual teaching, one of which is the department teaching electromagnetism.

Physics undergraduates start their electromagnetism course in the second or third semester after enrolment. They study electrodynamics in the sixth or seventh semester. The content of the two courses are linked with the degree of difficulty gradually increasing as each course is pursued. Teaching objectives vary by stages and different teaching modes can be chosen according to the students. Students have the right to choose bilingual or non-bilingual teaching. Through practice, experience has been gained gradually.

BILINGUAL TEACHING OF ELECTROMAGNETISM

Organising Electromagnetic Bilingual Education

In ordinary provincial colleges and universities, newly enrolled students' English proficiency is normally much poorer than is the English proficiency of students at national key universities [1]. Therefore, bilingual education is inadvisable for these students early in their studies at college or university. But, after one year of learning English at university, students should be better prepared for bilingual teaching. Hence, staff engaged in teaching electromagnetism, started bilingual teaching of electromagnetics and electrodynamics for physics department students. In order to better

implement bilingual education, the two courses needed to be adjusted and their lesson plans integrated. At the end of the electromagnetics and before the electrodynamics teaching, students previewed an English version of the electrodynamics material. Noting students' right to opt in or out of bilingual teaching, the class was divided into two, i.e. a bilingual class and a non-bilingual class.

In bilingual electromagnetics teaching, the proportion of English is chosen according to the teaching content. The aim is to strengthen the understanding of English content, covering physical concepts and terminology. The current textbook used by the teachers includes English translations of the Chinese text in brackets. The proportion of English teaching is increased for the more straightforward parts of the course. This adds interest for the students and improves their scientific English.

The electromagnetics and electrodynamics courses of the physics undergraduate programme were selected in which to use bilingual teaching during the spring and autumn of 2008. Each of the two teaching classes was divided into two tutorial classes, viz. one for bilingual teaching and the other for traditional non-bilingual teaching. The bilingual teaching classes used English language textbooks [3] and multimedia courseware [4]. The teaching content and teaching materials were synchronised with the non-bilingual classes. Bilingual education teachers should have oral expression in English similar to that of native English speakers, so that students can be exposed to an authentic English-speaking environment. Of course, splitting classes into two increases the need for teachers and classrooms, thereby negatively affecting the popularity of this arrangement.

Methods Used in Bilingual Education of Electromagnetics

One method used in the process of bilingual teaching, was to place students into groups where free discussion in English was encouraged. Usually, this group discussion continued outside the class. Another option was to use multimedia to make the teaching content richer and more colourful. Combining spoken English with images is very interesting for the students and greatly improves the effectiveness of the teaching. For example, the reflection and transmission of electromagnetic waves at an interface was simulated using MATLAB (Matrix Laboratory from MathWorks Inc.), with English comments accompanying the simulation. Not only can multimedia provide a wealth of animation, but it can also provide a contrast between the Chinese and English languages, and also cater for students with different English language proficiency. What is more, in using bilingual education the teaching tasks were successfully completed within the allocated time.

Figure 1 shows transmission where there is a quarter-wavelength matching layer. This was taught via mathematics, animation and a small amount of English notes. The electromagnetic theory is as follows.

When the thickness of medium 2, $d = \lambda_2 / 4$ and the intrinsic impedance of medium 2:

$$\eta_2 = \sqrt{\eta_1 \eta_3}\,, \tag{1}$$

Then the equivalent impedance of multilayer medium η_{ed} has value η_1. The wave reflection coefficient at the interface between medium 1 and medium 2 is:

$$\Gamma_1 = 0 \quad . \tag{2}$$

Zone 2 is called a quarter wavelength matching layer.

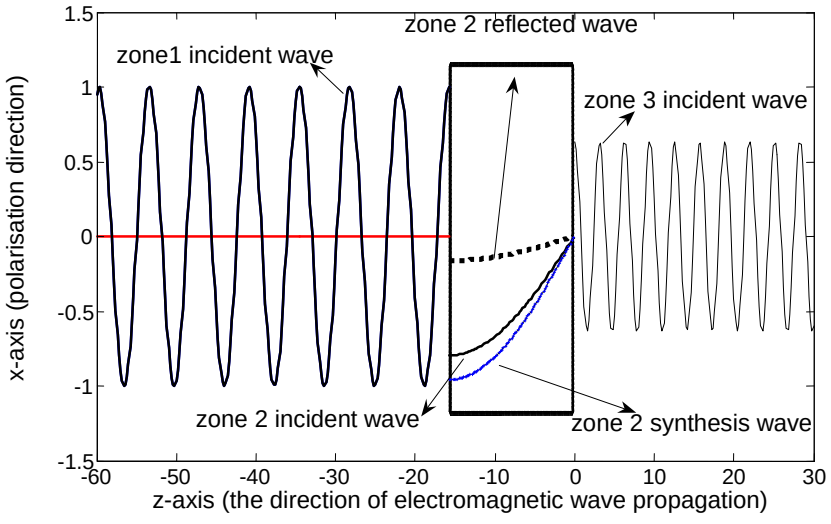

Figure 1: Comparison of bilingual teaching of electromagnetic wave propagation through three zones, with a quarter-wavelength matching zone.

The teaching using animation and some English notes helped students to understand English better, but it has also helped students to think in English.

DEVELOPMENT OF ELECTROMAGNETIC BILINGUAL EDUCATION

Selecting English Teaching Materials

Bilingual teaching is made more difficult if there is only a Chinese textbook and no corresponding English material. In practice, the bilingual teaching reported here used English textbooks; the teaching was in Chinese first and, then, in English. The proportion of English was increased gradually, so that teachers and students had a period of transition from Chinese to English. The proportion of the teaching using English material took account of the students' proficiency in English. A number of textbook references were used. These included *Electromagnetic Field Theory Fundamental*s (Bhag Singh Guru; Hüseyin R. Hiziroğlu, China Machine Press); *Introductory Electromagnetics* (Herbert P. Neff) and *Electromagnetic Field Theory* (Bo Thidé).

Proportion of English Used in Bilingual Teaching

Little or even no English may be used if the teaching is covering a fundamental physical principle or if the teaching content is very difficult. But, the derivation of formulae can be taught using the original foreign language since there is not much text and it is fine if it is in English. Overall, in teaching electromagnetic theory to physics undergraduates, the proportion of English in bilingual education should exceed 50 percent [5]. Electromagnetics and electrodynamics involves many equations and, since mathematics is in effect its own language, there is only a small need for English; although going through mathematics, with some English explanation, could enable students to use English for reasoning and deduction.

Oral English Training by Doing Electrical Experiments

Oral English was used in carrying out electrical experiments. The course experiments were conducted in the laboratory, with the teacher and students communicating face-to-face in English; hence, strengthening students' oral English.

A basic electricity experiment is given here to indicate the nature of such experiments. This example involves finding the magnetic field on the axis between two Helmholtz coils. See Figure 2 for the layout and definition of the major terms. The two currents in the coils generate magnetic fields B_1 and B_2 given by:

$$B_1 = \frac{\mu_0 I a^2}{2[a^2 + (L+z)^2]^{3/2}}, \qquad B_2 = \frac{\mu_0 I a^2}{2[a^2 + (L-z)^2]^{3/2}} \tag{3}$$

The two fields are of the same direction and the combined field strength $B = B_1 + B_2$.

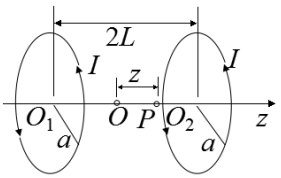

Figure 2: Helmholtz coils.

With one coil, the magnetic field on the axis is shown in Figure 3.

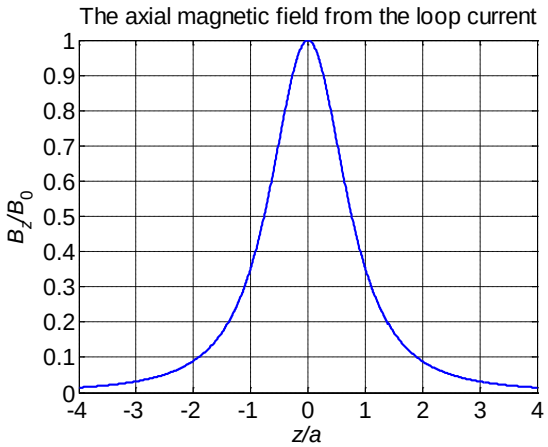

Figure 3: The magnetic field, with a single loop current.

Figure 4 shows the magnetic field on the axis between the two coils for various ratios of the distance between the two coils *2L* and the coil radius *a*. The blue and black curves (in colour printing) are the fields for each of the coils separately, while the red curve is the combined field. When the ratio was 1, there was a near-uniform magnetic field over a large region on the axis between the two coils.

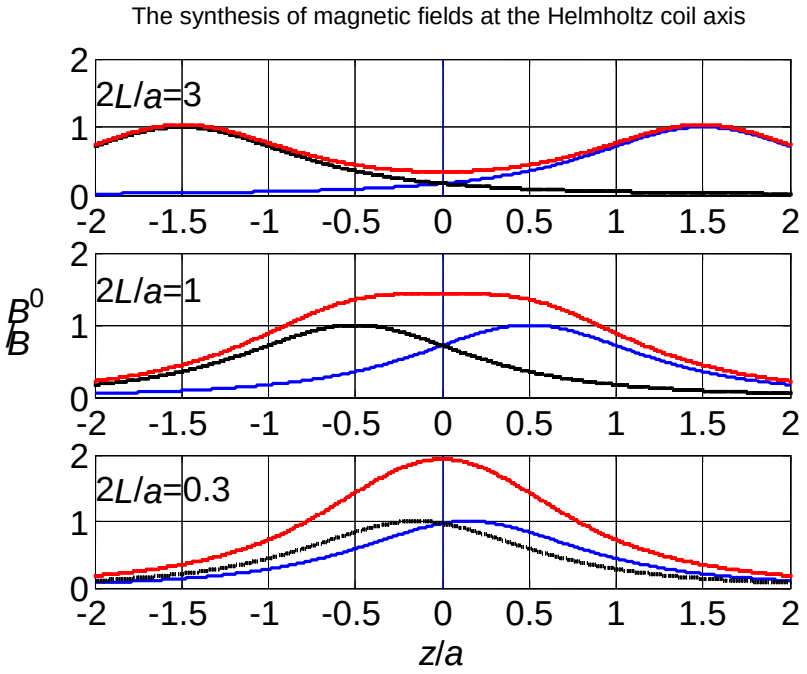

Figure 4: The magnetic fields distribution of the Helmholtz coil.

CONCLUSIONS

Bilingual education in local colleges is still at the exploratory stage. Lessons have been learnt through bilingual teaching of electromagnetism. On the one hand, there is a need for bilingual teaching, while on the other hand students find it very difficult, and it needs more teachers to persevere with it.

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