First language interference: a guide for teachers of mathematics

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Introduction

The delivery of mathematics in English to classes of students whose first language may not be English is present in many countries including the UK, where the language of education is English, but the population may have varying levels of English competency, as it may be a second, or even third, language.

I teach adults in a Further Education college in the England, and in the last few years about 25% of my students have been English language learners (ELL), half in discrete Functional Skills Mathematics classes for ESOL (English for Speakers of Other Languages), where exam questions are structured around applications of mathematics in 'real life' situations. The other half are in GCSE (General Certificate in Secondary Education) Mathematics provision. These mathematics qualifications are generally taken by 16-18 year olds, and are used as requirements by Higher Education for university entrance, hence the need for adults returning to education to gain the necessary grade for a successful onward journey into, say, teaching or nursing.

The impact of the language content and structure on students' ability to engage with the material in mathematics classes and exams is surprisingly high, and can reduce students' mathematics demonstrations of competencies significantly.

This is not intended to be a comprehensive guide to all of the differences between English and other languages, but to help raise awareness of the extent and content of those differences. Of course, this is just one barrier to learning that our adult students may experience.

Sources of Information

Initially my research was of a purely observational nature. I became aware of the impact that the English language was having in terms of a negative effect on pass rates for low level English speaking students. For instance, a student might come out at one level on a maths initial assessment containing few word problems, but struggle to complete a lower level diagnostic assessment, where more word problems were included, and need to go even lower if their language skills were considerably below those contained in the maths questions. This observation is confirmed by other practitioners in mathematics classrooms (Kersaint, Thompson, & Petkova, 2013).

This led to a growing realisation of the importance of language levels in the maths questions, and a more language focussed teaching style. I then realised, and I am not alone in this, that the resources I was producing for the ESOL learners were appreciated by the English speaking learners, especially those with lower levels of competency (Adler, 2001).

Research work centred on this area led me to a publication by a number of writers with another first language, but high English competencies, about the differences between their first languages and English. This book was edited by Swan and Smith (Swan & Smith, 2001), and is a comprehensive guide covering over 20 specific languages, including Arabic, Chinese, Polish and Spanish, and some language clusters, such as Dravidian (includes Kannada, Malayalam, Tamil and

Telugu), Scandinavian (Danish, Norwegian and Swedish), and West African languages (including Hausa, Ibo and Mende).

There are other works written about the English language that have also proved useful in extending this knowledge (Swan, 1995) (Crystal, 1995). It is unfortunate that, although we have more than a quarter of a million words in the English language, and more words are being added all the time, we seem to have no body that oversees the quality of the content, as exists in Germany and France. This seems to have led to the proliferation of single words that have more than one meaning, only one of which is mathematical, such as product, factor, modal and chord. There are also specific mathematical terms which students have to learn, such as integer, factorise and indices.

The importance of thought and discussion as aids to learning mathematics has been explored by a number of academics and practitioners, which has led to the view that restricted thought or talk can lead to restricted learning (Sfard, 2008) (Barwell, 2009) (Woolley, 2013). This has implications for my students: do I encourage thought or talk in their first language, and then translation into English (Adler, 2001) (Kersaint, Thompson, & Petkova, 2013), or do I insist on discussion in English? If the former, how much does this exclude those learners who do not have anyone who speaks their first language (Newmarch, 2005)?

This led me to view mathematics learning as a triad: Procedural competence, conceptual understanding and language learning. I have applied this thinking to all my classes now, even if they are 100% English language speakers, because I believe that the language can often be a barrier to comprehension and progress for adult learners.

I owe a debt of gratitude to my colleagues and students for additional information and knowledge. Any errors are, of course, my own.

Where individual languages have been referred to in this paper, I have placed them in alphabetical order.

First Language Interference: Impact on Learners

Two case studies illustrate the actual impact of language differences:

The first example is of a learner where the mathematical ability was far greater than was shown by his maths work in English. This was a student with a Master's degree in mathematics in Poland, a Level 7 qualification, who just passed an Entry 3 qualification in the UK, which is below Level 1. This shows the impact of the language on achievement, as this adult learner was compromised eight levels of mathematics by his English language skills, which were around ESOL Entry 1.

The second case is a Chinese student's experience of moving to the UK to continue his studies in Mechanical Engineering at a university in England. He dropped his degree course in at the end of the first year because he failed the maths exam. In China they do not use Greek letters for formulae, and he was unable to change from the Chinese to the European system using Greek letters, such as mu (μ), in time.

This led to a realisation that it is not just the English language, but also the mathematical language or symbolism itself which may impact on how successful learners are when studying mathematics in English (Kersaint, Thompson, & Petkova, 2013) (Woolley, 2013).

As a teacher, I also need to be aware of the cognitive load on students, and how asking students to multitask in the classroom can impair learning (Ashcraft, 2002). English speaking students are likely to be drawing on a substantial knowledge about the construction, content and meaning of the phrases and questions they are given. Those without first language English may be focussed initially more on the translation, and an understanding of what is required, before they reach a stage where they can process the mathematical content. At the very least these students may need more time to cover the same amount of work (Swan & Smith, 2001).

Findings of Potential First Language Interference

In this section we will look at some of the many differences between English and other languages, in terms of sentence structure, words and sounds before progressing to evaluating mathematical symbolic, procedural and terminological differences (Crystal, 1995) (Swan, 1995) (Swan & Smith, 2001).

Sentence Structure

Sentence structure is very different between languages, Written language may not be from left to right, as it is in English, but can be from top to bottom, as it is in Chinese and Japanese, or from right to left, as it is in Arabic and Urdu.

Punctuation is not present in all languages, for instance in Arabic, Korean and Thai a gap is often left instead. Punctuation use can differ between languages, for instance there is no possessive apostrophe in French, and so in French we can only say 'the learner's work' by using the whole phrase, which would translate as 'the work of the learner'. In German and Scandinavian languages a comma is often placed after the verb in a sentence, but in Turkic languages it is placed after the subject of the sentence; in English it is used to separate phrases. In Hindi a full stop is a vertical line.

In English we use upper case letters at the start of sentences, and for proper names, such as Dublin, Monday and September. In German all nouns are written with an uppercase letter, so that would include car (das Auto) and house (das Haus); in French and Spanish days of the week and months start with letters in lower case, so 'lundi', or 'lunes'. In Italian the days of the week start with a capital letter, but the months do not.

Many languages have no upper and lower case format, including Arabic, Chinese or the Sanskrit languages, such as Bengali, Farsi, Hindi, Punjabi and Urdu.

English seems to be unusual, in that the nouns do not have a gender, as is the case with most of the languages mentioned above. Nouns in many languages can be masculine, feminine or neutral, which affects both the spelling and pronunciation of words such 'the' and 'my', and how adjectives attached to the noun will look.

In many non-English languages when nouns are used as objects in a sentence they take their gender with them. Hence you may find that learners will translate 'She has lost her bag', as 'She has lost his bag', if 'bag' in their first language is a masculine noun.

The order of words within sentences is also a challenge for many learners moving from their first language into English, as it is often different from their first language. When Yoda in 'Star Wars' says to Luke Skywalker "Found someone, you have", he is translating from his first language, rather than using his knowledge of English language word order. Different word order, where

sentences are start with a verb, is also present in Arabic, but in Sanskrit languages, Tamil and Turkic languages, the verb comes last.

Words

Continuing the verbs theme, the verb 'to be' does not exist in Arabic, Thai, or Turkish. In some languages the use of 'to be' and 'to have' are switched, so learners may say, and expect to see, that they 'have thirty years old, rather than they 'are thirty years old'; this includes French, German, Italian and Polish.

The verb 'to do' does not exist in languages as disparate as the East African languages, French, German, Hindi, Italian, Punjabi or Urdu. This is a very common verb in English appearing in many ways in questions and instructions.

Languages differ in their use, and even the presence of articles, such as 'the' and 'a'; for instance 'the' does not exist in Japanese, Russian, Turkish or Urdu, whilst 'a' does not exist in Arabic, Hindi, Malay or Urdu. Other languages, such as French, German, and the Scandinavian languages can use articles differently, so will say 'The human beings are strange' rather than 'Human beings are strange.

There can be less or different use of prepositions in sentences, such as in, on, under, at, for, of and so on, in most languages, including those in northern Europe, Turkey, and the Arabic speaking world. Describing the location or position of an object comes in at the lowest level of mathematics assessment in the UK, namely, Entry 1.

Countable and uncountable nouns, and their quantifiers, can also be different in many languages, including those of Africa, France and Scandinavia. In English words such as news, trousers, pyjamas and scissors are always plural, but information, advice, expenditure, time, money and hundred are always singular. This is not the case in other languages, so you may hear 'two hundreds' rather than 'two hundred', and learners may be confused by the lack of a plural if they see 200 written in words.

We seem to have a proliferation of words in English where elsewhere perhaps only one word will be used, including hear and listen, find and look, lend and borrow, which and what, some and any, much and many. This can add to the complexity of translation for lower level English speakers.

Comparatives and superlatives are another area of difference, as not all languages, such as Turkish, differentiate between them, for instance between taller and tallest, of older and oldest, but this is very common in English, and is an expected skill at Entry Level 1 mathematics.

The use of questions containing negatives should be used with great caution in class, as different languages have the opposite response to what we might expect in English.

Some words genuinely occur in more than one language, for instance 'oval' is the same word in Bulgarian, Romanian and English, but other words are classified as false friends: they may look and sound like a word in another language, but in that language they actually mean something different. Examples of these include 'no', which in Polish is an informal version of 'yes' or 'tak'; in Scandinavian languages 'rent' means rate of interest, and an 'offer' is a sacrifice; 'sensible' in French and Italian means kind or sensitive, and 'lecture' means reading. There are many more examples of false friends across many languages.

Sounds

English has a Northern European alphabet, which differs from Eastern Europe and Russia, and is very different from elsewhere in the world. The sounds that the letters make, even when the letter is the same, often seems to be different between languages, i.e. in Polish the 'e' and 'i' sounds are reversed, as are 'v' and 'w'. This can make pronouncing a word like twelve more demanding than it looks. Some languages, such as Chinese, German, Spanish and Turkish have no 'w' sound at all, so mispronunciations can occur. Dutch speakers, however, tend to soften the ends of words, so the 'v' sound becomes an 'f'.

As a native English speaker, I can hear the difference in the pronunciation of second language English speakers, and equally, if I learn another language, first language speakers of that language will hear differences in my pronunciation; this is what gives us accents in another language. It is notoriously challenging to acquire new sounds later in life, and the early years are known to be crucial for developing an understanding of the sounds of a language. Other languages have sounds that do not exist in English, and vice versa.

English has many vowel and consonant clusters which are not present in other languages, which add to the challenges of speaking and listening. For instance the 'th' sound so ubiquitous in English does not occur in Danish, Dravidian languages, Farsi, French, Irish, Norwegian, Polish or many West or East African languages, hence the number of learners who struggle to pronounce words like thirteen or thirty.

In a number of languages including French, German, Irish and Spanish it is common to use a mark above a vowel to change the sound, rather than use vowel clusters, as we do in English. These marks can be called accents or umlauts. It is unfortunate that English has no consistency of use of vowel pairs, as we can hear in the difference in the 'ou' sounds in 'ouch' and 'cough'. There are many other examples of this lack of consistency, which all add to the work load of learners.

The stress placed in a word can also lead to it sounding different, and languages differ in where they place the stress in words and sentences. For instance in Japanese each syllable is pronounced equally, but in English the stress is usually on the second syllable of a word.

The endings of words are often not heard in Chinese or French, and the languages are adapted to cope with this, but in English it is often critical to hear the ends of words or the meaning is lost, as in the difference between 'thirteen' and 'thirty'.

Mathematical Symbols, Procedures and Terminology

There are a number of ways in which symbols and mathematical procedures differ between countries and languages, in addition to that given at the start on the use of Greek letters for formulae. These include a variation between the use of the comma (,), and the full stop (.). In non-English languages generally the use of these punctuation marks in decimal numbers, including money, and large numbers is reversed, i.e. Three euros and fifteen cents is commonly written as E 3,15 but three pounds and fifteen pence is written £3.15. Also 100.006 will look like 100 point oh, oh, six to English speakers, a decimal number, but one hundred thousand and six to many other people.

The division symbol differs in the UK and USA compared to the rest of Europe; in the former it is written as ÷, but in the later it is written :. This is potentially very confusing to learners, as we use : for ratios. The way division sums are performed is also different on the European continent, and does not involve changing the position of the numbers in the division sum. Given the

issues that many adult learners seem to experience with division there may be some justification for evaluating the two methods to see if the 'rest of the world' method improves retention and understanding.

Traditionally in the English speaking world a dot placed between two numbers about half way up the numbers signifies a decimal point, but in Poland this is the symbol for multiplication, as it can be in the UK in higher levels of mathematics.

Rounding and estimation seem not to be present in languages that are pictorial, where one character has a meaning, such as Chinese and Japanese. My Chinese learners tell me that is pointless to move from one character to another before calculation, as it just increases their work load, so they are resistant to estimation and rounding, even in English.

Many countries, such as Spain, do not use the 12 hour clock, only the 24 hour version, so learners will need to be taught how and when they are used in English, otherwise it can lead to errors in time calculations, as learners understand something different when they translate the sentence or question.

There are further differences in time as in many languages, including German and Norwegian, 1330 would translate literally as 'half two', but in English we say 'half past one' often shortened to 'half one'. Perhaps 'half two' has been shortened from 'half to two'.

In English we can classify numbers as odd or even, but it is much more usual in other languages to say even and not even, as in Italian, 'pari' and 'dispari', or Spanish, 'par' and 'impar'. An issue here for my learners was that odd and 'dispari' or 'impar' are in different places in the sentence, which led to them misunderstanding and reversing the meanings of odd and even.

Some words have more than one meaning in English, a 'normal' one, and a mathematical one. One example of this is the word 'product', which is used to mean an article that was produced, and is used for something we put on our hair, but in mathematics the product of two numbers means multiply. Other challenging words include table, change, expand, factor, modal and chord. All of these words have a general meaning, which differs from the quite specific mathematical meaning. Many native English speakers are also confused by this terminology.

A further set of words have specific mathematical meanings, and whilst they do not have the confusion of another meaning attached to them, they do need to be learned for success. These include such words as integer, factorise, indices and circumference.

The language of word based maths problems is clearly a factor in whether learners are successful, or not.

Impact in the Classroom

Some understanding of the issues faced by mathematics learners who are not learning in their first language, but in English, has caused me to make a number of changes to my teaching practice. For instance I now routinely put definitions of key terms on the board, leaving them up for the whole session.

Online translation tools up on the Smart Board can be very useful, as they can show words and phrases in almost everyone's language. This can help raise awareness about the different challenges that learners face, especially minority groups in the classroom, and create a more "culturally respectful learning environment" (Kersaint, Thompson, & Petkova, 2013, p. 139), where

differences are seen as interesting and positive. The use of book and electronic dictionaries is also encouraged, although only paper based dictionaries are permitted in exams in the UK.

Displays incorporating all the languages present in the classroom around, say, key vocabulary, such as addition, subtraction, multiplication and division words and symbols, also helps in this process.

Pictures to illustrate and support the language in word problems can be very helpful, saving time on explanation or translation. In cases where the words used have more than one meaning they are particularly useful, such as completing a design for the location of stalls at a fair, or working out how much wood is needed to construct a shelf. This can benefit the English speakers as much as other learners in sessions (Adler, 2001).

Signposting learners to internet materials, such as the BBC Skillswise and Bitesize web sites, Khan Academy, You Tube videos and the British Council's ESOL Nexus website, along with my college's VLE (Virtual Learning Environment), is done in the second week of the course. Learners are very mixed in their use of these, owing often to differences in the availability of equipment, or competence with IT, but they are used by around half of my adult learners.

Some of the internet sites have language support modules in addition to mathematics content, such as BBC Skillswise and ESOL Nexus.

There is also a role for phone apps, such as Tessify and Block Puzzle. Some phone apps have no or very little language included, relying on a worked example to show the techniques required, but if they do have instructions in English learners may be able to access these in their first language, or they could use on line translation sites, dictionaries, or electronic translators.

Speaking in a clear voice, avoiding repetition and non-completion of sentences may also help learners understand what is required of them, as will repeating explanations slowly and carefully whilst you illustrate with an example. Changing the language used to explain an idea or concept can increase the confusion for learners, as now they have two sets of words to translate.

Conclusions

In conclusion, there are many ways in which a first language can impact on a learner's success in the mathematics classroom, and can interfere in the successful acquisition of English for mathematical purposes.

This interference can arise from differences in sentence structure, in the words that are available, along with their common first language usage, and in the sounds and intonations that are available to learners. Interference can also arise from a difference in mathematical procedures and symbols, and from both words that are specific to mathematics, and those which have more than one definition, a common feature of English.

An awareness of the issues and challenges learners face has raised an appreciation of the cognitive load many learners face in a mathematics classroom, where the content is delivered in a language that is not their first, or sometimes even second, language.

Finally, the focus on language and definitions can be seen to benefit all adult learners, including those who speak English as a first language, because of the amount of specialist vocabulary in mathematics classes. In mathematical problem solving the context can be critical to comprehension, and this is often only obtainable from the language.

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Construct a football with Origami - discover the hidden mathematics in a paper football

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Firstly, I introduced the practical activity and gave some background. Practising to discover hidden mathematics within our familiar surroundings plays an important role in continuous learning and to enjoy and enrich our lives. In this workshop we saw how learners can be helped to experience the joy of solving mathematical problems such as the 'Four Colour Theorem' and Euler's polyhedral formula, by constructing an origami football with regular triangles.

More polyhedrons can be built using regular triangles, e.g. regular tetrahedrons, regular octahedrons and regular icosahedrons. Furthermore, when leaving gaps between connecting regular triangles one can construct truncated tetrahedrons, truncated octahedrons and truncated icosahedrons. The origami football that the learners constructed in this workshop was a truncated icosahedron. This was a very practical approach to create polyhedrons which is different from building it from a net of polyhedrons.

Secondly I discussed the importance of using practical activities in lessons. Mathematical problems are written with the condition that they are solvable - especially practice exercises which are guaranteed to have certain mathematical solutions. By constructing tangible paper