Making Maths curriculum more accessible: Strategies for children learning EAL

How can EAL learners begin 'to speak Mathematics' (Barwell, 2007). In one sense taking this literally enables us to question how children internalise the language of Mathematical discourse. There are certain activities especially those relating to vocabulary associated with abstract concepts (e.g. problem solving) that some pupils learning EAL find challenging. We also know that all children develop their mathematical skills more when involved in inclusive collaborative activities, especially those that invite active participation. Examples from primary classrooms supporting this approach are plentiful. (www.naldic.org.uk). There is a widely shared view amongst classroom practitioners that good practice for EAL learners is good practice for all children' although we might argue that good practice alone, and this itself is open to interpretation, will not secure learning for all bilingual learners. But are there strategies that can be developed to use children's bilingualism as a primary resource?

Our key aim in this short guidance is to explore the role of children's first languages in developing their understanding of abstract mathematical concepts. We will explore this through examples of some recent and ongoing research in the field. We will mainly focus on Key Stage 1 and Key Stage 2 although some examples will also be drawn from Key Stage 3.

QTS Standards

Q1 Q2 Q10 Q14 Q15 Q18 Q19 Q22 Q23 Q25

The Primary National Strategy (DfES,2003) acknowledges that language provides the means for children to conceptualise mathematics as well as develop their own thinking. The key questions we will address in the following discussion are;

- How can this principle also apply to bilingual children and their home languages?
- To what extent can bilingual children transfer their existing mathematical concepts into English?
- In cases where these concepts are not sufficiently developed, can the home languages be used to explain/clarify complex mathematical concepts and terminology?

Mathematical challenges for bilingual learners and for teachers

There is ample research to support the cognitive advantages of bilingualism (Peal and Lambert, 1962; Diaz, 1985; Cummins, 1981, 1996). There is research which looks at specific pedagogical approaches that are relevant to second language development (Cummins, 1989; Gibbons 2002, Issa, 2005; Leung, 2006;). There is also some Government documentation suggesting that supporting the development of the mathematical aspect of children's home languages is likely to have positive outcomes for their mathematical learning (DfES, 2002). In schools where resources (staffing and other) exist which facilitate this process, the outcomes for the learning for pupils learning EAL can indeed be positive. However, not all schools work under similar conditions. The challenges faced by teachers vary and are influenced by different factors. We list some of these below:

- Children learning EAL have various levels of bilingualism. In some cases their spoken (home) language may be well developed while this may not be the case for their literacy in the same language.
- Children may refuse to use their home languages despite coming from bilingual homes. Here we need to consider the influence of the 'peer group' where talking in a language other than English may not be perceived as 'cool'.
- The ethos of some schools may discourage the use of the home languages
- Staff who are monolingual cannot be expected to use bilingual classroom strategies. We need to explore teachers' role as facilitators of children's cultural and linguistic experiences. Mathematical concepts are contextualised through forming meaningful links with pupils' everyday (home and community) experiences. We will explore this further as we look at teachers' changing roles in this respect.
- The availability of appropriate tools for the assessment of children's mathematical skills in their home languages. Although this can prove to be a challenging task if there are no bilingual staff to carry out such an activity, tasks can be devised which are not dependent on levels of English fluency.

The challenges that are presented to bilingual learners whose major source of formal learning is in their second language are obviously many. As part of our research we carried out a survey involving twenty Maths specialist teachers working in primary and secondary schools in three London Local Authorities (Hackney, Islington and Haringey) and observed ten lessons, 5 in Primary (KS2) and 5 In secondary (KS3) contexts. Our observations and teachers' comments suggested that pupils learning EAL have found the following aspects of mathematical language the most challenging.

- Specialist mathematical vocabulary e.g. equilateral, probability, remainder, estimate, division, sum of

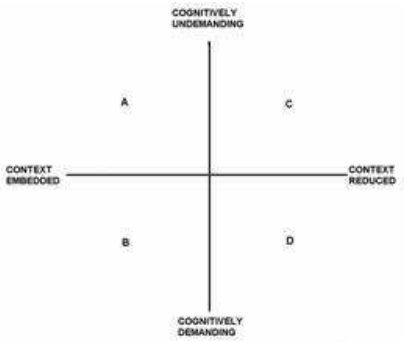
- The use of everyday words in mathematically specific ways such as volume and difference, evenly, more than, less than, the value of.
- Specialist syntactical features x for KS1/2, such as 'if' and 'then' of, and, or, a, if and however.
  For example:
  What happens if we make this angle smaller?
  First add the two sides, then divide the product by two.
  What is the product of 12 and 23?
  It is possible to take children's understanding of these words for granted especially when some EAL learners use them frequently in their everyday conversations. Application of their meanings to 'mathematical thinking' may require some careful consideration, discussion and negotiation by teachers and pupils.
- Demands when working with mathematical symbols such as (≡) (≠) (≤) (≥), and their meanings as part of a specialised vocabulary
- Ways of talking, including spoken and written forms of mathematical explanation and the demands of the social context of mathematical problems

Developing communicative proficiency

Ease of access to mathematics also depends on the type of mathematical problem the child is attempting. Cummins, (1981) explores communicative proficiency in terms of two continua; cognitive demand and context embeddedness. Barwell (2007), in particular, notes the assessment activities that are most challenging. These include written investigation, textbook exercise and, more challenging still, formal written and mental arithmetic tests.

Much mathematics depends on the capacity to understand written problems. Indeed the major type of summative assessment used in primary schools, SATs, depends on the capacity to work with and solve word problems. This type of activity is high in the context reduced and cognitively demanding classification of activity (Cummins, 1981). A key question, therefore, is; What approaches will help bilingual learners to work independently and confidently with word problems?

Cummins' (1984) 'four dimensions quadrant' (contextual and cognitive) provides a very useful framework for planning for bilingual learners.



(Cummins 1984)

As Cummins (1981b) suggests this represents a way of thinking about communicative proficiency. The horizontal continuum refers to the amount of contextual support available to the pupil. Context embedded learning opportunities exist when there is a good degree of support in communication, including via body language. Cummins' examples include 'pointing to objects, using the eyes, head nods, hand gestures and intonation'. We could summarise these as providing plenty of visual cues for children learning EAL. Cummins suggests that such approaches make content meaningful and accessible. Teachers who plan highly interactive Maths lessons with plenty of visual support, animation and gestures are paving the way for introducing more abstract, or using Cummins' terminology 'context reduced, cognitively demanding', tasks. For example, if pupils are to learn about the properties of a square, it would make sense for the teacher to provide plenty of opportunities for children to:

- Handle a square object
- Engage in short practical (comparative) activities to discover what makes a square different from other shapes e.g. rectangle, trapezium, rhombus etc.
- Look around the class to find shapes, which are similar or identical.
- Encourage pupils to 'show and tell' their discoveries. Here, the presence of an actual object not only reduces demands on pupils to produce mathematical vocabulary, it allows the teacher to carefully support and introduce appropriate mathematical vocabulary to complement the parts of the shape displayed.
- Respond to carefully devised questions about the properties of squares reinforcing the subject related vocabulary/ concept (e. g. a square has four identical sides).

Practice and implementation; use of first language by pupils and teachers to probe and consolidate understanding

Some teachers and teaching assistants may be monolingual or in cases where they are bilingual themselves, unable to speak children's home languages. In the case of children learning EAL whose literacy skills in their home language may not be well developed, we need to focus on their surface level (spoken) communication which often includes language used in everyday peer group interactions. These interactions are often dominated by language reflecting pupils' cultural and linguistic experiences. Can there be strategies to facilitate the use of children's language skills in such cases? We provide some examples below to support this point.

Example 4.1
Although some children may not have highly developed literacy skills in their home language(s) they may have good oral skills. These skills can be utilised and turned to children's advantage. For example, if we consider the activity about properties of squares above, a monolingual teacher or teaching assistant can help children make the 'conceptual transfer ' between the home language and English. One of the ways this could be done is through reflective questioning (in English) where children are asked to think about the same concept/vocabulary in their home language(s).

In thinking about the properties of a square, the teacher may focus on the word equal as part of the key vocabulary by asking children to think about finding the same concept/ word in their own language. This will enable them to use their linguistic repertoires to construct meaning and enhance their own conceptual development. Here, the teacher should be willing to provide children with cues to help them narrow their search by giving them related words such as the same, identical, not different that would evoke similar meanings. This generates an automatic 'reinforcement mechanism' within the child's 'central operating system' (see Cummins' Iceberg analogy, 1980a) as they try to devise a mental picture of the concept. Regardless of whether the child is successful in establishing the link or not the outcome is positive as the very process sets into motion the process of internalisation of the concept i.e. the child is actively thinking about forming an association of the same concept between languages.

Consider the question 'What do two 'equal' lines look like?' Through seeking a corresponding word in the home language children are supported in making sense of the conceptual challenge through drawing on existing linguistic tools. This is where visual cues are important as they help children to form the association between what they are given as abstract words. The teacher provides concepts and visual representations that would help children to make the conceptual and linguistic links. This could be in the form of a range of examples such as:

- Two lines of different lengths with a simple question, 'are these the same length?'
- Showing a rectangle with a question 'this shape has some sides which are equal. Can you colour the ones which are the same/equal?'
- Putting three lines with lengths in cms. and asking, 'can you pick the two lines, which are the same/equal?'

----------3cm
----------5cm
----------3cm

Example 4.2
The teachers' role is very important as children need to be engaged constantly in interactive communication while they are given opportunities to verbalise their thinking processes. This is shown in the following dialogue from a year 5 Maths support class at Waltham Forest Turkish school. The teacher taking this session is a bilingual Gujarati/English speaker working at the school.

Teacher: So what sort of words do you use to mean 'the same' or equal in Turkish Ahmet?
Ahmet: Well we say if two people or two things look the same they are *ayni* (literal meaning: same) or *esit* (literal meaning: equal).
Ayse: But we also use it for people like husband and wife… like they are the same. I mean we say they are *esit* meaning men and women are equal. I heard my mum say to my dad *Erkekler ve kadinlar esittir*. (Men and women are equal).
Teacher: I see… so which meaning would you use to talk about the sides of a square then?
Ali: I think we can say *ayni* no?
Ayse: We can also say *esit* because it fits better I think.
Teacher: Why do you say it fits better?
Ayse: It's hard to describe… in Turkish you can say *ayni* as well but *esit* really fits better. I prefer *esit* because sometimes *ayni* can mean similar but when you say *esit* it means they are *tipatip ayni* (literally: identically same).
Sevil: *Evet. Dogru, tipatip ayni* fits better 'cause it means exactly the same as the other one (Yes, that's right. Identical fits better 'cause it means the same as the other one).

It is interesting to note the way Ayse chose to end her last sentence with a Turkish loan word *tipatip ayni*. We listened to the conversation between Ayse and her teacher. She was asked why she chose to use a Turkish word instead of an English one, she said 'I know I could have used the English word there but '*tipatip ayni*' describes what I want to say best. Ayse's point was reinforcing Vygotsky's (1962) theory about language and its use in social contexts. Here, Ayse is not only selecting the 'best' vocabulary to describe what she wants to say but is actively

engaging both of her linguistic channels transferring, validating and organising her thought processes. Sevil's code switching can also be interpreted in the same way where she chooses the most relevant and sometimes most readily available vocabulary. Here, we are referring to situations where the speakers may only know the word in one language, making the switch more of a necessity rather than a choice.

The role of teachers as facilitators is clearly shown in this example. The teacher is not a speaker of Turkish and yet he was successful in activating children's linguistic systems by asking relevant and inquisitive questions.

The example referred to an interaction between the teacher and a group, however the same strategy can also apply to a single child from another language group. Here having a teaching assistant who could speak the child's language would be ideal but this is often difficult in schools with limited resources. However, it can be done with a monolingual classroom assistant with a clear brief from the class teacher.

Practice and implementation; awareness of cultural and social dimensions

Example 5.1
The following example is from a pilot project in a secondary school in Haringey aimed at delivering KS3 Maths National Curriculum through the medium of Turkish and English to a group of Turkish speaking girls as part of an after school Maths club. The teacher undertaking the programme is a qualified Maths teacher working at the school. She is also a fluent Turkish speaker. She teaches the same group during the day and makes note of special areas, which cause particular difficulties for Turkish speaking children exploring these later in the club. A full project report can be obtained from http://www.londonmet.ac.uk/depts/doed/centre-for-multilingualism/

The teacher uses Turkish to explain the meaning of a specific mathematical term, which usually appears as part of a word problem. In one of the sessions we attended the word estimate was causing particular difficulties for most of the children in the class. The teacher explained the process firstly using Turkish equivalent words tahmin, yaklasik and giving real life examples as to how this could be used in everyday situations

Teacher: *Mesala, kendinizi Tarkan konserinde düsünün. Kim gitmisti burdaki (Londra) son konserine Tarkan'in? Salonun kapasitesi yaklasik 2000 civarinda. Bu nedemek? yani salona sigan seyirci sayisi tam olarak bu rakam degil ama ona yakin* (For example imagine yourselves at Tarkan's concert. [Tarkan is one of the most popular singers in Turkey]. By the way who went to Tarkan's last concert here (London?). The capacity of the concert hall is estimated as 2000. What does this mean? Well it means that a number of people that it can hold is around that figure).

Mehmet: *Yani az mi fazla mi?* (So does it mean more or less?)

Teacher: *Esasinda bu tam olarak bilinmedigi icin veya soru icin cok onemli olamadigi icin az da olabilir çok da. Yani size salonun yaklasik olarak nekadar seyirci alabilecigi uzerine bir fikir vermesi icin soylenmis. 'Capacity' yani 'Türkcede 'kapasite' olarak geciyor. Burada tahmin ediliyor,* (You see because this is not really known or because it isn't very important for this problem it is used to give you some idea about how many people this hall can actually hold. It can be more or less. The word 'capacity' or '*kapasite*' in Turkish is used in for this reason. It is an estimate. They are giving you a rough guess here.)

Arzu: *Kapasite' bu Fransizca'da da ayni ogretmenim* (It's also the same in French, Miss).

Teacher: *Çok dogru. Aferin Arzu* (Correct! Well done, Arzu).

In this particular example the teacher chooses to contextualise the problem by making it relevant to children's experiences. The topic 'their favourite pop singer' immediately evokes some natural interest giving initial focus. The teacher is using what is familiar in order to explain the unfamiliar. Here, familiar is both the topic as well the language used. The use of conversational Turkish both helps contextualise the problem as well as enabling children to identify it with something they already know (i.e. the place where their idol had a concert). This set of dynamics immediately sets children up for what is to be presented as a new piece of information.

The role of Turkish is very important here, particularly for monitoring the effect of the (teaching) input as well as pupils' learning. It is opening an additional channel into pupils' thinking devices. There are numerous possibilities to do this, where a teacher focuses on one group and notes down key points of discussion and key vocabulary used (teaching assistants can be valuable extra resources here). Plenaries provide children with opportunities to verbalise their thinking as well as inform teachers of the impact of their strategies.

Many teachers we spoke to during our research indicated that when they had time to explain mathematical problems through relating them to children's cultural experiences they got more responses from the pupils e.g. A flight to Cyprus takes 5 hours and 15 minutes. It needs to stop over in Istanbul (Turkey) for refuelling. If it takes four hours for a plane to reach Istanbul, how much journey time remains before the plane touches down in Cyprus? This was one of the examples given to a group of Turkish speakers by a Maths teacher in one of the secondary schools in Haringey. The school has a large Turkish student population. The assumption here is that most of the children in the group visits Turkey or Cyprus regularly but the example can clearly be contextualised to match the experiences of different pupils.

Example 5.2
It is clear that children need support to work through the concrete to abstract thinking 'stages' in order for them to cope with formal situations and work with textbooks. The Realistic Mathematics Project in the Netherlands has developed the work of Gravemeijer (1994) in his quest to help children develop different levels of mathematical skills. He calls this mathematisation. As part of this project the initial experience involved children working through mathematical problems in a familiar context, such as getting on and off the bus. Many mathematical situations/vocabulary etc can be modelled through this process. In UK, a similar project was developed using children's cultural experiences through handling concrete resources to help their understanding of concepts. Here children worked in collaborative groups and were given opportunities to use both languages in role-play situations (Issa, 2005). Children were years 4 and 5 in an inner London primary school. The concepts under investigation were profit, cost, buying and selling.

In this project children were given equal sums of money towards stocking their grocery shops and were asked to compete with one another to see who would sell more items. Most of the children in the project came from families who owned different shops selling food or other items. Children usually visited their parents' shops and experienced shop transactions in various forms. In the classroom children were given freedom to set up their shops, label their products, decide on the price and sort out their responsibilities in their shops. The teacher acted as a facilitator introducing conflict scenarios by acting as a customer 'complaining' of the higher prices and pointing at the shop around the corner that 'sold the same items cheaper'. This sort of prompting enabled children to think critically about 'reducing' or 'increasing' their prices in order to attract customers. Data collected clearly showed how collaborative thinking and decision-making facilitated children's mathematical development (see transcript)

Practice and implementation; use of multi-sensory materials

A large majority of the teachers taking part in the survey said the use of multi sensory materials enhanced their pupils' participation. We have seen many activities using interactive whiteboards. The most successful of these had high pupil involvement as shown in the following example from a primary school in Hackney. The session was on triangles.

Example 6.1
Teacher- Ok! We all agreed this is an isosceles triangle right? Who will come and turn this into an equilateral triangle on the white board?

In this particular session children were given opportunities to come and manipulate the images on the whiteboard in order to get the right shape. The key to this approach was shared learning involving the whole class. The child learns the properties of the shape by manipulating the sides on the whiteboard and through the backing of his/her classmates. Learning becomes a shared as well as an interactive process. The use of ICT offers limitless possibilities in this respect. Children with limited English language skills are able to explore their existing mathematical knowledge in the home language without relying on abstract mathematical thinking. Such activities also provide opportunities for teachers to assess children's existing skills as creating a secure trial and error situation enables children to feel happy to come and try things out on the board. Once more we would like to highlight the role of teachers and other adults in instilling EAL learners' confidence.

Concluding Remarks

When we are looking at specific strategies to support children learning EAL we need to take account of their bilingualism. Children's language competence, in English as well the home language, will vary and this variation needs to be taken into account .

Cummins' quadrant is an aid to planning through;

- Use of first language by pupils in clarifying concepts and exploring vocabulary
- Use of culturally familiar and relevant examples
- Use of visual cues, including gesture, diagrams, concrete examples etc.
- Extensive use of peer talk in collaborative contexts to clarify and question understanding
- Use of a range of examples to illustrate and clarify a concept

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