RAISE project case studies – Kirklees (2)

Access for All in Mathematics and Science

Three projects in secondary science and mathematics departments to examine the role of questioning by teachers; the importance of key words; and the potential of collaborative learning

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This paper was contributed in 2004 to the RAISE Project. There is background information about the project at www.insted.co.uk/raise.html.

Introduction

A series of action research projects were carried out in three 11—16 schools in Kirklees between September 1998 and July 2002. The research focused on investigating which strategies and approaches would raise the achievement of multilingual students in the context of the teaching and learning of science and mathematics. The action research projects aimed to:

- identify the language demands of the subject at Key Stage 3 and 4
- implement strategies to enable students at various stages of English language development to access the curriculum
- consider the implications of findings upon action planning at departmental and whole school level.

Rationale for the programme

In order to achieve the aims of the research it was important that the teachers involved had a common baseline of understanding regarding the language and learning demands of mathematics and science for all learners. This was to be addressed through two days inservice training for each department delivered by the Kirklees LEA's central EMA team. Training covered language and learning in mathematics and science.

Whole subject departments—rather than individuals within them—were involved. Further, a partnership teaching approach was adopted by means of which subject and EMAG funded teachers jointly planned, delivered and evaluated the curriculum as equal partners. Thus it was intended that the research project within each school would have a high profile.

It was anticipated that this approach would encourage staff to be mutually supportive. Having larger numbers of teachers involved would facilitate discussion between colleagues both within the project and beyond, thus generating interest and ultimately effecting the wider dissemination of the research, as it progressed.

An essential part of the research programme would be the provision of continuing support from the EMA central team in the form of half-day tutorials every half term. This support would encourage the researchers to sustain interest and motivation, whilst supporting them to develop rigorous research.

THE RESEARCH PACKAGE	
School-based INSET	2 days
Tutorials (maths only)	4 half-days (half-termly)
Writing up	2 half days
Final evaluation	1 day

Teachers were supplied with a research toolkit to support them in becoming confident and independent researchers, and in developing an analytical approach to the research. This common use of tools and approaches gave the research rigour and enabled comparisons and conclusions to be drawn.

On a half-termly basis staff came together for half-day tutorials in order to evaluate research to date; share findings at departmental level; evaluate research tools; consider implications for future practice; and start the process of drawing conclusions. We offered models of evaluation and analysis, which demonstrated reflection and reflexivity and the need for supporting evidence. At the end of the project, the research team and the partners shared their evaluation with the EMA Advisors.

The first objective was to provide all members of the subject departments and the schools' EMA teams with two days of intensive training, which would give them the knowledge, skills and understanding necessary to undertake this research. The training, whilst examining theoretical models, emphasised and exemplified their practical application in the context of the teaching and learning of mathematics and science. The training programme covered the following areas:

- overview of language development
- an analysis of the language demands of mathematics and science
- strategies for access
- short term planning
- application of access strategies in mathematics and science: examples
- identification of access strategies
- research methodology
- partnership planning.

Identifying a target group

Each subject teacher was asked to identify a target group within their class. This acted as a focus for observation and evaluation, even though the planning was for the whole class with the target group being part of the differentiation. The needs of the target group were identified using a range of information including: National Curriculum levels; scores on ELDA (English language development assessment—a tool for assessing English language development along a ten point scale); student profiles; and their language backgrounds. These identified needs helped to inform planning and differentiation.

Teachers developed case studies that included examples of planning, teaching, observation notes and evaluations. After trialling, teachers evaluated these strategies and approaches, drew conclusions and made recommendations.

The strategies and approaches described are considered to be generic in that they may have multidisciplinary application and relevance. They are also considered to have equal relevance and application to the education of students who do not speak English as an additional language, since they reflect the principles of planning for differentiation. The research projects were therefore entitled, 'Access for All in Mathematics' and 'Access for All in Science'.

The LEA's English language development assessment tool, ELDA, is a cross-curricular and cross-phase tool, which aims to assess competence in listening, speaking, reading and writing along a ten-point scale (see Appendix 1). It also supports the identification of the next steps individual students have to take in order to progress to higher levels of achievement in both their English language development and their subject knowledge and understanding.

Evaluation

During planning, consideration of the levels of English language development and other performance measures (such as NfER scores, SEN information and SATS results) of individual students was found to be useful in gauging how much understanding students might have or might be able to absorb. This, in turn, helped researchers to consider if there was a need to adjust the delivery of lessons. Where adjustments in delivery needed to be made, researchers considered appropriate access strategies and how they might be applied. The use of ELDA levels also enabled researchers to focus on those students who would require greater support in concept formation.

Separate assessment of listening, speaking, reading and writing can highlight the fact that development may not be equal in all these four language skills. Researchers reported that this alerted them to the fact that individual students' needs would vary depending on whether the work had a literacy or oracy focus. As a result, it was acknowledged that there was a need to produce differentiated worksheets to support students at different stages of development in literacy.

In mixed-ability settings, the use of ELDA levels was found to be indispensable in informing the organisation of groupings and pairings within the classroom, where students in the early stages of English language development were often

grouped with those who had more advanced English. It was hoped that these students would then act as mentors and provide models of English language.

In one school at the end of the first term, departmental policy was followed in placing students into 'ability' sets, as determined by results in their school assessments. In the 'higher ability' sets, ELDA levels were found to be higher and similar. However, on examining the NfER quantitative scores of students placed in set 2 and comparing them with their ELDA levels, some discrepancies were found. Some students with high NfER scores had not performed well in the school assessments and consequently had not been placed in set 1. It was thought that their relatively low ELDA scores might partly explain this. This became a focus for research: Did the students fail to gain the expected results because the language of the questions had held them back?

LDA levels were considered as crucial in planning for differentiation even in 'ability' sets, where there was still enough of a range in each set for it to be a useful tool when used in conjunction with other measures. For example, a teacher for a Year 8 top set explained:

> Cards on percentages were produced for an oral cyclical timed exercise, which differentiated in language and level of difficulty. All students found this exciting and were able to successfully take part, regardless of ability, provided that the strategic distribution of cards was ensured by the teacher.

In a Year 7 set 4, ELDA levels ranged from 4 to 8. It was felt that all students needed assistance with tasks relating to reading and recording but it was recognised that those students lower down the scale would continue to need additional support. However, in speaking of all sets, one teacher felt that:

> Lessons of an appropriate level could only be planned if we had a complete class profile detailing information from SATS scores, NfER results and ELDA levels for each student in the group.

There was broad agreement with this view.

Departmental conclusions

Consideration of the stages of English language development—as assessed using ELDA—is very useful when planning because it supports the teacher in determining the linguistic needs of the group, as well as in deciding how those linguistic needs may be met. In mixed-ability settings, students' ELDA levels inform decisions about the variety of groupings—mixed-ability, similar-ability, shared language and mixed language—that the teacher may wish to use. When teaching students in ability sets, students' ELDA levels highlight for teachers the need to match to the language development of their students the language they use in the delivery of lessons and the tasks they set.

Departmental recommendations

- At the beginning of the year, automatically include ELDA information on set lists.

- Use students' ELDA levels to inform planning and differentiation.
- Reassess when appropriate.

- Consider ELDA levels along with other measures of performance in order to make diagnostic assessments.

- Use ELDA assessments to review the reliability of subject assessments and placing of students in sets.

- Include ELDA scores in mark books, as well as a central department reference.

- Use ELDA information at the end of the school year to inform whole school planning for the following year.

Questioning techniques

Strategy

At the start of each project, researchers were asked to plan into their tasks the most appropriate form of questioning. It is often thought that open questions are always the most effective for allowing learners to demonstrate understanding and learning. However, researchers were asked to support students along a continuum by giving them the opportunity to show understanding through responding non-verbally, and by responding to closed questions, optional questions and open questions.

Closed questions (for example, 'Has this increased?') provide a clue to the expected response, the potential for a one-word response or even a mere nod or shake of the head.

In an optional question (for example, 'Has this increased or decreased?'), the answer is still embedded in the question and, because the language is also modelled in the question, the student is supported in the production of new language.

An open question (for example, 'How did this change?'), whilst being accessible and appropriate for some students, may place others in a situation where it is not possible to show understanding. This leaves the teacher only with information about what the learner cannot do and nothing about what the learner can do.

Researchers were also asked to be aware of the difference between closed and open questions, and between closed and open problems. A closed problem is a problem for which there is only one correct solution (for example, 'What is one fifth add four fifths?'). However, this problem can be posed either through a closed, an optional or an open question:

- *Is one fifth add four fifths one whole? (closed question)*
- *Is one fifth add four fifths one whole or five? (optional question)*
- *What is one fifth add four fifths? (open question)*

Other examples are:

- Is this a mammal? *(closed question)*
- Is this a mammal or a reptile? *(optional question)*
- What class does this animal belong to? *(open question)*
- What features of a reptile does this animal have? *(open question)*

An open problem is one for which there are many solutions. Open problems can be presented in a way that also allows for solutions to be offered through a non-verbal response.

Show me how you would set up a fair test for investigating how well materials conduct heat.

Researchers were also asked to consider how their questioning techniques could be used to support students whilst they were engaged on tasks.

Did you decide to use this method because of X? (closed question)

- Did you decide to use this method because of X or because of Y? *(optional question)*
- Why did you decide to use this method? *(open question)*

The different question types should therefore be used at the discretion of the teacher given that the teacher is uniquely placed to understand the needs of individual students.

Evaluation

Researchers used the whole range of question types in their teaching in order to differentiate between the needs, language levels (as determined by ELDA assessments) and abilities of all the students in the class. Researchers acknowledged the benefits of varying question types during all stages of lessons and in different types of lessons: introductory, developmental, review and summative. It was also felt to be valid for all groups, whether mixed ability or similar ability.

It was felt that by using closed questions during introductory lessons and recapping sessions, the teacher was able to receive immediate feedback from students who were thought to be in the greatest need of support, on whether they had already formed certain concepts or on whether concepts that had recently been taught had been understood. For example:

Do we use centimetres to measure angles?

For other students open questions were considered useful in order to give them the opportunity to express their level of understanding. For example:

Who can tell me anything about angles?

These questions were put to the class during an introductory lesson on angles where the teaching partners were aiming to ascertain prior learning.

Optional questions were used to check basic understanding but, in particular, to model mathematical terminology and therefore correct misuse:

Is this an obtuse or an acute angle?

In summative sessions, the following questions were posed in order to offer a variety of styles and to differentiate between students of differing abilities and at different levels of English language competence:

- Is this an obtuse angle, an acute angle or something else?
- What sort of angle is this and why?
- Is shape A a reflection of shape B or a rotation?
- Could it be both?
- What is the difference between area and volume?

By varying the question types posed to different students and ensuring that no one student was allowed to dominate, researchers reported that they were able to focus on those students who did not normally volunteer and elicit responses from them at the appropriate level. This resulted in what appeared to be an increase in student confidence and enthusiasm, and contributed to the

development of an interactive approach in the classroom. The fact that responses were elicited, even if incorrect, allowed researchers to identify areas of misunderstanding and by handling those responses positively explore with the whole class the possible sources of confusion.

A focus on the teacher's questioning led to a recognition of the importance of asking students to question each other both in oral interactions and by writing questions for each other. This entailed producing language using the correct terminology and demonstrating an understanding of related concepts. During student modelling, other class members frequently asked questions providing an opportunity for a range of students to develop oral skills. One class was asked to devise a set of four questions on percentages and percentage change as a group exercise. The researchers reported that it was interesting to observe how difficult they found it to word their questions so that their peers could understand and solve the questions correctly. Because such tasks give students practice in thinking about the language of examination questions, it was felt that this would also ultimately contribute to their success in answering questions.

The learning objectives for each lesson were shared with students in the form of closed questions. For example:

Can I use correctly the rules for solving algebraic equations?

In some cases, researchers questioned their students on whether learning objectives had been met. In others, these questions were displayed and students invited to sign up at any point in the lesson when they, as an individual, felt confident that they had achieved particular learning objectives. Researchers felt that this successfully evaluating the effectiveness of their teaching. In one class where students were given a questionnaire, approximately 90% of students agreed that the teacher telling them what they should learn by the end of the lesson had been very helpful.

Departmental conclusions

Directing different question types to different students, as appropriate, allows all to participate in lessons regardless of their stage of English language development. This strategy is valid for all groups and with students of all abilities in all curriculum areas. It gives access to those who need it whilst allowing others to extend their understanding by being required to give lengthier and more complex responses. By matching questions to the ability of students, the teacher helps to increase students' confidence and self-esteem. The display of lesson learning objectives, posed as closed questions, encourages students to evaluate their own success and identify any learning objectives they might not have yet realised.

Curriculum area recommendations

- Continue to consider the use of different question types in the classroom in order to effect 'on the spot' differentiation.

- During planning, continue to identify learning objectives phrased as closed questions and share them with students.

- Ask students to evaluate whether the learning objectives have been met and use their evaluations to identify the next steps for individuals, groups and whole classes.

Key words

Strategy

Researchers were asked to identify during planning the key language that students would need to understand and apply if learning objectives were to be met. The teachers would then consider how this key language would be promoted within the delivery of the lesson: by the display of key words (both in English and heritage languages), and by teachers being consistent in the language they used—for example, 'multiply', not 'times' or 'effervesce' not 'fizz'.

Key words can be displayed in the appropriate languages through the original script for that language along with a transliteration into Roman script and a translation into English. Supporting visuals can also help to make understanding easier.

Evaluation

Researchers acknowledged that, prior to the research, key words were not given such a high profile. By the end of the research, this strategy was being used to support teaching to introduce new vocabulary in every lesson. Researchers reported that the use of key words had a significant impact on the understanding of mathematical and scientific language.

The students were encouraged to use the key words and were praised for using them. They appeared to take delight in correcting a teacher who did not use the correct subject specific terminology. In this class, students had reached a point where they expect to use new words and enjoy using them correctly.

Some teachers found that by referring to displays of key words and asking questions, students were able to demonstrate their understanding of the terminology of mathematical vocabulary. For example:

> Which word means that an angle is more than 90 degrees and less than 180 degrees?

Key words, sometimes with supporting visuals, and sometimes within definitions, supported students in producing appropriate mathematical/scientific language. They had acted as a scaffold and enabled them to succeed in their tasks.

Some researchers noticed that sometimes, on entering the classroom, students were spontaneously discussing the key words in a display. The displays also gave an opportunity to students who had difficulties with reading and spelling to take a more active part in the lesson. Another researcher planned for students to create their own glossaries of subject specific terms, as lessons progressed.

One pair of researchers reported that the use of key words had supported students in developing higher order language skills, as they confidently explained the difference between the word 'term' in everyday language and the mathematical word 'term'. In fact, almost all students agreed that they had learned by having words and phrases in mathematics explained by the teacher and others.

It was also found that by leaving the words on the walls, regular reference could be made to them thereby linking one area of the subject to another and helping students to retain knowledge by recalling previous lessons.

Another researcher found that displays could have additional benefits. He asked Year 8 students to produce their own display of key words—to address his concerns about otherwise patronising them—and these displays had advantages for other students who worked in the same room. The teacher could use them with other classes to introduce topics and stimulate discussion, as well as using them as a tool for reinforcing the learning with the original class.

Other researchers asked students to brainstorm definitions before then displaying them in the classroom and along the corridor. An advantage of displaying key words in the corridor was seen to be the fact that students could 'test' themselves on the words whilst walking along the corridor and before they entered the classroom.

In another activity, students were asked to match words correctly with their definitions, which were displayed on cards. The additional benefit of this technique was that it also allowed less confident students to respond non-verbally.

Students were found to refer regularly to key words displayed in the room and it was felt that this had contributed to their ability to identify different types of triangles and different classes of animals correctly. Some students were able to name and describe, others to name but not describe, and yet others to describe but be unable to recall the correct names. One teaching partnership observed that some students thought that they might be 'cheating' if they referred to displays of key words.

During planning, not all the key words and phrases identified were subject-specific. For example, 'conducting a survey', 'preparation', 'explain and discuss'. The latter two examples were discussed in detail.

> Can you tell me what we mean when we say 'explain'? How is it different from 'describe'?

Researchers felt that a focus on key words during planning led them to emphasise those words during lessons.

> … and the correct word for this is…

This resulted, in turn, in an increase in students' use of accurate language both in discussions and in writing. Activities, which involved the accurate transfer of

information such as 'jigsaw' groupings, also placed demands on students to use correct terminology.

Although during training it had been suggested the key words be displayed in heritage languages—along with a transliteration in Roman Script—some researchers found this to be more of a challenge. Some researchers expected to use translations of key words. However, it proved difficult to find reliable translations. Others were concerned that very few of the multilingual learners were literate in their heritage languages—in which case, if the language uses a non-Roman script, the student would not be able to read it. It was evident that students were using the key words in English since it was observed that, during discussions in Punjabi, students code-switched to use words such as 'correlation' and 'median'. They felt that this was evidence of student's understanding through the use of both their languages.

In one school, although key words were used in English, some teachers felt it unnecessary to use key words in heritage languages because there were no students who were beginners in English and students were observed to be reluctant to use their heritage languages in class. However, students of African descent were observed to use Patois when discussing their families during an activity based on Caribbean islands.

Departmental conclusions

The identification, use and display of key words is an important consideration if students are to understand and use subject-specific language correctly and with confidence. Students are found to use the correct language more regularly when key words are displayed and referred to. The use of translations of key words and their transliteration merits further investigation. The continued and possible increased use of key words has significant time and budget implications for the subject departments, as well as the deployment of EMAG-funded bilingual staff.

While translations of key words can be found at basic levels, they are more difficult at higher levels of teaching and learning. Specialist language then needs to be in English as concepts are first grasped in English and, even during discussions in heritage languages, there is code-switching to English specialist terms. Discussion of difficult problems in heritage language was found to be useful, particularly in the early stages of English language development.

Departmental recommendations

- Continue to identify and use key words.
- Investigate the use of translations and transliteration of key words and its effectiveness.
- Set up systems for investigating the use of bilingual staff and the contribution they may make to planning and the production of resources.
- Establish a system for sharing the production of durable and re-usable displays of key words amongst curriculum area staff and an indexed resource base to ensure ease of retrieval.
- Build into the departmental budget the cost of these resources.
- Identify key language in English.
- Consider groupings and pairings carefully in order to facilitate discussion in heritage languages.
- Encourage students to use suitable alternatives in heritage languages.

Purposeful grouping

The strategy

Teachers were asked to consider when it would be appropriate for student to work together on group tasks. The project focused on:

- mixed ability grouping
- similar ability grouping
- shared heritage language grouping
- mixed heritage language grouping.

Researchers were asked to consider, during planning, how grouping strategies could encourage student to offer each other peer support. The rationale is that peer support encourages students to engage in purposeful talk about the subject content. The demand upon the students becomes one where they are encouraged to produce language—rather than solely play the receiver—that is, they are asked to explain or share their ideas. The aim for the teacher is to encourage students to look to each other as experts and to develop an ethos where all contributions are valued. This strategy is also likely to empower students to take responsibility for their own learning.

Teachers were asked to consider opportunities for peer support in a variety of groupings: from paired work, through to group and whole class situations. For

grouping to be truly purposeful, it must be decided by the teacher, even where the decision is to allow the students to select the groups themselves and must be flexible. No single approach to grouping is appropriate for all tasks, situations and contexts. Pupils' personalities may be another consideration in the rationale for grouping. Depending on the task, teachers need also to consider the size of group and the number and type of resources required.

In order to develop students' English and mathematical concepts, teachers were asked to plan for mixed language grouping as and when appropriate. This would provide opportunity for students to share their thoughts and ideas in English, as this would be the common language for communication.

Evaluation

Two researchers used information about pupils' ELDA stages to inform their mixed ability groupings. They felt it was important to create opportunities for pupils to support each other. Teachers tried to ensure that the groups had enough skill, in terms of language and ability, to allow all pupils to contribute. Consideration was also given to the personalities within the groups.

Initially, the pupils were not supportive of each other. Over time, pupils were seen to work more positively with each other. One pupil with low literacy skills was seen directing other pupils and other pupils could see that his contributions were valid: this appeared to raise the confidence of the directing student.

The partners in this research project concluded that mixed ability grouping facilitates peer support. Students can develop the confidence to admit what they do not understand, knowing support from peers will be forthcoming.

Another two researchers used their knowledge of pupils' ELDA stages and ability in maths to organise their mixed ability groupings. During work on conducting surveys, pupils were observed sharing their skills to produce letters, gathering and recording data, and giving information on results.

Teachers said that pupils, after initial reluctance to work with each other, found working in these groups to be much more acceptable. They considered a variety of factors, including gender. One bright but disaffected boy worked better with girls. He remained on task and tended to be less chatty than when with boys. The researchers will consider gender when planning groupings in the future.

In another study, the researcher had organised a mixed gender and mixed language group. There was no difficulty in pupils working in these teacher-selected groups because she shared the rationale for the groupings with the students. She stated clearly that they were not negotiable. The students accepted that they would be working in different groups at different times, as selected by the teacher.

She grouped two boys, who were shy and lacking confidence, with a hard working pupil of average ability. This grouping provided structure for the two shy boys. Another student was to act as mentor to the other two boys. It was hoped that he would develop an empathy with the other students in the group. He could appear to be arrogant at times. The teacher noticed that one of the girls,

who was shy, started to be much more confident about her ability. She felt the encouragement she received and working with others helped her to blossom.

The pupils worked in largely mixed ability groups and mixed gender groups. The seating arrangements had changed so many times that she felt the students had lost sight of 'what their group was'. Where pupils were given a choice of working partner, they opted to work with someone of the same gender.

Because teachers in one partnership had observed that some of the students did not like working in larger groups, they planned for students to work in pairs. Sometimes pupils of similar ELDA stages worked together and, at other times, students were paired with others who were at a different ELDA stage. It was observed within one partnership that the weaker students benefited from the peer support.

When working in larger groups, pupils worked within a full range of abilities. This was seen to be effective. Groups collaborated to plan surveys for a particular audience. The students were asked to choose their audience and context for the survey. Language levels varied within the groups and students were observed co-operating and sharing their skills.

Researchers found that, for peer support to be successful, it was essential to develop within classrooms a positive ethos through praise and encouragement. Teachers wanted to develop an atmosphere where everyone had the right to be listened to and where it was recognised that everyone had something to offer.

During the research, peer support took place in a number of different contexts. Students shared ideas to find solutions to problems in whole class situations, in group work and in paired work.

In one instance, researchers said students found the idea of peer support very difficult because they perceived it as 'cheating' and took some time to recognise its value. Over the period of research, they were encouraged to help each other and discuss problems they found to be difficult. The strategy eventually has fed into lessons beyond those that were targeted for the research.

Grouping students for paired work, with tasks that encouraged them to discuss or describe problems, allowed teachers to find out what the students knew and understood. The teacher was freed up to observe what students knew, understood and could do. For example, one pair of students was observed offering solutions to a mathematical problem which they were asked to discuss in pairs. They were trying to explain what an equation is and explain how to solve one. Observation of students showed that where this pair had a problem, they discussed at length and finally a solution was suggested using the correct terminology:

> If you've got an even number, you will be able to divide it by two and there will be no remainders.

The teacher could see that the students took their work seriously, taking turns in answering questions on the discussion sheets. They were focused and followed the instructions carefully.

Often the less confident student will ask his/her peers for help, rather than ask the teacher. It was observed in one class that some students were very shy and the researchers felt the students would have found it stressful to speak in a group. In order to develop their confidence they were asked to share ideas with a partner. This culture of working, where students offered each other peer support, was promoted as they entered school in Year 7. This expectation was consistently planned for to the extent that, by the end of the project, most of the students would willingly volunteer information and answers without the fear of being ridiculed by other peers—and still continue to do so. When students made errors, teachers noted comments of sympathetic support and prompting.

As research progressed, it was observed that students offered information, guidance and help to each other. They appeared to have gained confidence from each other as they appreciated each other's contributions. One pair of researchers noted supportive comments made by students such as:

- That's a good way of doing it.
- I hadn't thought of that.
- Can you help me and show me what to do?

This supportive context may have contributed to a whole class ethos of appreciation of ideas and contributions, and may reflect increased confidence.

In another class, mixed ability groups of four were created to complete activities on percentages: students were asked to set questions for circulation amongst the other groups within the class. In another instance, students were asked to prepare display work about 'prisms', 'nets' and 'volume'. Some students demonstrated strengths in their practical work. For example, some weaker students were able to shine, even when teamed up with the more able ones who would normally dominate the group. They were able to represent 3D shapes accurately. These skills were appreciated during group work.

Two researchers identified a drawback of peer support, when there was a wide range of abilities within a group—such as when a potential top set student was paired with a student who had a statement. This was observed to cause frustration on the part of the more able student, who tended to pursue the extension work provided, leaving the other student to her own devices.

Another important consideration was group size. It was observed that some students 'sat back' and let others do the work for them. The researchers reflected that this might have been caused by the size of the group: there was not enough work for each member of the group and work was not differentiated enough, reducing access to the task. In other cases, more able students sometimes dominated discussion. In response to these concerns, the researchers used jigsaw groups: each member of the group was responsible for gaining some information to pass on to the group as a whole. They considered the rationale for groupings in future lessons.

Some researchers were keen to use jigsawing as a key grouping strategy in a number of lessons. 'Expert' groups were set up, the experts were then split up and regrouped to form new groups where expertise was shared. It was difficult—but crucial—to get groupings in both the working and reporting groups correct. The working group had to be of similar ability, in order to deal with the differentiated tasks; usual friendships had to be dissolved where possible, and a gender and ethnicity balance introduced. One group, working on a particular task, was reluctant to form a proper working group. They did not sit closely to one another. In general, however, teachers found that gentle persuasion, together with being very open about sharing the aims of tasks, were all that was needed to overcome diffidence.

It was important that each group had a positive pupil role model who could, without dominating the work, 'get the group going' and on task. The reporting groups then had to have one pupil from each working group, thus becoming a mixed ability group. Nevertheless, they also needed a race and gender balance, and, once again, at least one positive pupil model. The teachers believed that this was an intricate, but worthwhile task.

Throughout these lessons the students knew, and were often reminded, that when they went back to their reporting groups they would be the only one who knew the task or its solution and that they would be expected to explain both of these to others.

There were problems with the reporting back part of the jigsaw lessons. The pupils did not have enough time to do this. Teachers felt that this could be because the pupils did not feel allegiance to their reporting group, having only performed one short exercise with them at the start of the first lesson. The teachers felt that this part of the jigsaw could have been improved with greater structure to the reporting back—perhaps by giving students questions to work through, similar to the tasks, each one led by the relevant pupil.

Observations confirmed the truism that, to understand a problem fully, one must be able to explain it to someone else. For example, a student was observed explaining how she worked out percentages for a problem:

> So look, I've bought a house at 100% of its cost – that's obvious isn't it? Do you get what I mean? And then it's sold at 5% profit – so that's 100% isn't it? So if 105% is £75,600, we can work out what that 100% was.

Another student was observed sharing how to work out a calculation:
'So if you go one mile in one minute, then that's 60 miles in 60 minutes per hour.'

It was noted that jigsawing led to more pupils being more focused on the tasks for longer than would normally be the case.

Departmental conclusions

This strategy was seen to be very successful, particularly with younger students who appeared to be more receptive to new approaches. Discussions arising from paired and group work enable students to clarify their knowledge. Teachers felt that the strategy had helped to increase students' confidence, as they could draw on support from each other. It is crucial to group students carefully so that they are all challenged and each student has a role to play in the task set. This strategy provides an excellent vehicle for communicating Mathematical concepts verbally.

Jigsawing was seen to be particularly effective. For this to be successful, it is important that groups are carefully planned beforehand and consideration given to the pupils' language development, skills and knowledge in relation to the curriculum, and their personalities. Where classes are not familiar with alternative groups, an appearance of randomness is essential.

Departmental recommendations

- There should be a departmental approach to planning for group work within different topics.
- It is essential that the pupils feel they have some ownership of how groupings are set, particularly in later year groups.
- Frequently encourage different groupings from Year 7.
- Use peer support throughout all year groups.
- Develop a classroom culture that will allow for students to feel confident in offering ideas and solutions, with the knowledge that they will be supported.
- Use peer support in a variety of ways: pairs; small groups; large groups; and whole class.
- Ensure that grouping strategies enable and encourage all students to participate whilst being appropriately challenged.

Same-language groupings

During planning, researchers were asked to consider when, and for what purpose, it would be appropriate to group students by heritage language. It had been pointed out during training that, for some multilingual students, the space to share ideas multilingually may allow them to discuss more readily ideas that could otherwise be more difficult to express in English. Mixed language groups do not necessarily encourage students to speak in heritage language, as the common language is English. Shared heritage language groups are more likely to encourage multilingual discussion.

Evaluation

In one case study, most pupils in the class were Punjabi speakers. Therefore, in most lessons same-language groupings were used more through necessity than design. Many of the activities covered during the project aimed to develop pupils' relationships with a wider group of peers.

A particular focus was providing opportunities for a pupil who had found it difficult to achieve integration, who was not chosen as a partner and chose to work alone on most occasions. The teachers identified a number of variables that may have affected this: he was the only pupil from his form group; he was the only Gujarati speaker; and he had a reserved character.

Although there were pupils in the group whose literacy skills were low, the majority had good English oral skills and they usually chose to communicate in this language. They did, however, draw upon heritage languages whenever understanding was not achieved. One pupil was observed explaining a correlation formula to another pupil when he eventually used his heritage language to support his explanation. In another instance, a pupil was seen asking a peer a question in heritage language possibly in an attempt to hide from the teachers his lack of understanding. It was initially thought that, on such occasions, the student was 'off task' but ELDA scores and other examples point to weaknesses.

These observations led the teachers to conclude that shared heritage language groupings can help pupils by giving them another avenue or strategy for problem solving but this needs to be developed from a young age and sustained so that it becomes a natural part of students' interaction.

In another partnership, the students in the set all had ELDA scores which were higher than 8. The teachers said that, consequently, English tends to be the language not only of their formal work in the classroom but also their language for informal speech. They are observed 'gossiping' in English as well. The teachers felt that it was therefore patronising to push the pupils to use their heritage languages.

Teachers thought, however, that students should be given every opportunity to talk as freely to each other as possible about their work. If grouping pupils with the same-language facilitates this, it is a worthwhile strategy.

Another teacher believed that pupils expect learning to be done in English. Heritage language is used for light conversation and social interaction with families. They distinguish between the language of classroom learning, which is in English, and everyday talk, which can be through their heritage language. By organising heritage language groups and pairs, teachers began to break down barriers to learning brought about by this dichotomy. It was observed that they began to use their heritage languages to facilitate problem solving and this appeared to be effective. When working on fractions, pupils were observed discussing in heritage language during problem solving as they cut a Battenberg cake.

The use of key words that were translated was not useful because pupils did not know words such as 'cross sectional area' in heritage language.

In later lessons, the teacher observed that the use of heritage language became more apparent. It was seen to be useful because it allowed students to bring their own experience into the classroom. For example, not having the words for 'tape measure' in their heritage language meant that out of necessity they used the word for 'string'.

Another pair of researchers felt that structuring tasks so that pupils worked in various groups on quite complex subjects had meant that there were occasions where they needed to draw upon their heritage languages in order to solve disagreements and misunderstandings. The pressure of wanting to prove their point caused some heated discussion and they naturally conducted discussions in their heritage language. Teachers felt that this was beneficial. For example, it was observed in one lesson that one pupil was 'off task' until another pupil then said, " Oh right !". He then got on with his work and engaged in discussion both in English and Punjabi.

Departmental conclusions

The teachers agreed that groups should be organised to fit the purpose and consideration should be given to when it might be appropriate to organise groups in such a way that pupils who share the same heritage language can work together. Encouraging pupils to work in heritage language needs the teacher to trust that the students will be productive. It should not leave the teacher feeling a loss of control.

Some researchers did not feel they needed to use this strategy. Some felt that the students did not have the level of heritage language required for mathematical discussion. It was observed that the students only used heritage language for 'chatting'. The teachers said that students were reluctant to use heritage language, even in subjects such as English. They felt it was only appropriate to use where beginners were present.

One researcher used same-language grouping to support beginners. She considered that the target group could have used heritage language, if necessary. They were not directed to do so, nor were they observed speaking in heritage language.

In another project, the teachers identified the languages of the pupils. When they organised mixed ability groups, they tried to organise shared heritage language pairs. This, they felt, was unsuccessful as students did not have the technical language in heritage language. They felt that the students were not comfortable and felt the situation was artificial. Referring to their heritage language, some students made comments such as, 'We don't use it at home.' They shared the view of their parents that, when you are at school, you should speak in English in order to improve it.

During work on coordinates, pupils of African-Caribbean heritage were observed using Patois when they were discussing their knowledge and experience of visiting the Caribbean islands. This led the teachers to reflect on the extent to which the inclusion of islands surrounding India and Pakistan in the task would have encouraged the Asian pupils to speak in Urdu and Punjabi. It is something they would like to try in future.

Departmental conclusion

Students need to become familiar with the same-language strategy consistently throughout their school careers so that it does not appear to be 'unusual'.

Mixed-language grouping

In order to develop students' English and mathematical and scientific concepts, teachers were asked to plan for mixed language grouping, as and when appropriate. This would provide opportunity for students to share their thoughts and ideas in English, as this would be the common language for communication.

Evaluation

All of the researchers planned for mixed language grouping. Where group work took place, some teachers considered the languages, language levels, and abilities of the students. In a top set of 32 students with a range of abilities, more able students were seen explaining more technical and specialist language spontaneously to other students, so that students could model for each other, ensuring exposure to a range of abilities and English language levels.

In one context, researchers noticed a reluctance among Year 11 students to work as a 'mixed language' group. This was because the students usually turned themselves into friendship groups and, as a result, there was a divide between the White students and the Asian students. When the teachers asked students to work with others that created a mixed-language group (consequently, a mixed ethnic group), some students protested that they preferred working with their friends.

Curriculum area conclusions

Researchers concluded that it is better to consider the mixed-language strategy with Year 7 students, as they could be less resistant to flexible grouping arrangements.

Mixed language grouping can encourage student to model both language and concepts.

Overall conclusions

The conclusions and recommendations drawn for each strategy or approach are, on occasions, repeated. This is probably due to the fact that observed outcomes were not necessarily as a result of the application of one individual strategy or approach in isolation but rather a combination of several strategies and approaches and their cumulative effect.

As the action research progressed, researchers noted from the mathematics curriculum area that the strategies and approaches being trialled in targeted classes had an equal relevance for other classes they taught. Some mathematics teachers initiated the use of similar practice when working alone.

The partnership teaching model appeared to be supportive of both specialists, given that the language development team is now considering working in a similar way with other curriculum areas. Both sets of teachers seem to have been able to build on the additional confidence they have gained through working as equal partners albeit in an area which was not their field of expertise.

The system for detailed joint planning and evaluation may have encouraged a cross-fertilisation of ideas as well as the development of mutual respect and the acknowledgement that each partner had a role to play in the professional development of the other.

The professional discussions that took place both amongst the researchers directly involved, and interest from other members of staff, had implications which were unforeseen and had an impact beyond the classroom. Some of these 'spin-offs' had implications for the policy and practice of the mathematics curriculum area, others for the school as a whole:

- each mathematics and science classroom to have a whiteboard where learning objectives will be written at the start of each lesson
- the identification and display of key words is now seen as common practice
- raised teacher awareness of the importance of students' attendance when sequences of lessons had such tightly structured planning
- monitoring of attendance in mathematics

- the establishment of a lunch time mathematics club
- raised student awareness of the importance of attendance at mathematics lessons and therefore in other subjects
- investigation of cross-phase tutoring of Year 7 students by Years 12 and 13 students at lunch time in the mathematics club
- creation of an ethos where students' needs are expressed and addressed
- awareness of the need to examine the reliability and validity of internal assessments for placement in sets.