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NUMERACY THROUGH LITERACY

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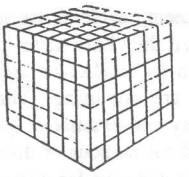
This is a report on a small research project carried out jointly by a Mathematics teacher (Clare) and an English teacher (Christine). We began this research because we were both interested in the role of language in the learning process. We wanted to explore how students use language in order to think through concepts, express and communicate their learning. We wanted to consider their use of language in both oral and written form. The format of pupils working through a mathematical problem gave us a vehicle for this exploration.

The Task

The group used in this research were Year 10 students, taught by both teachers. They were confident that they knew what was required of them in a mathematics investigation and were competent users of spoken and written language. The mathematics teacher presented the task and explained the requirements of the task. Much emphasis was placed on clearness of expression and working as a group. They were asked to be sure that everyone in the group, including the English teacher, understood their ideas and ways of working.

The task set was an investigation well known to mathematics teachers called "The Painted Cube." In this investigation, the students are presented with a cube that has had all its sides painted blue. They are asked to imagine the large cube sliced into smaller cubes, initially 216 smaller cubes, by cutting each side evenly into six. They are then required to investigate the numbers of these smaller cubes that have none of their faces painted, one of their sides painted, two of their sides painted and so on. They are asked to generalise their findings for other numbers of smaller cubes and provide reasons why these generalisations are true.

THE PAINTED CUBE



Imagine that the six outside surfaces of a large cube are painted blue. The large cube is then cut into 6 x 6 x 6 = 216 small cubes. How many of the small cubes have 0 blue faces?

1 blue face?
2 blue faces?
3 blue faces?
4 blue faces?
5 blue faces?
6 blue faces?

Now suppose that you cut the cube into n^3 small cubes.....

The Students' Activity

The students begin tentatively, working with their own ideas. They speak in short phrases, mainly just numbers. One of the group says: "Shall we just work out each of them?" By the general murmurings, it appears that the others in the group, except Christine, know what she means and agree to do that. Several times, Christine asks for an explanation of what they are doing but although they are polite, none of the students are willing to spend time explaining to her what appears to be common knowledge among the others. Twice, the student attempting an explanation for Christine is interrupted by another student and returns to a conversation with the others. The conversation is made up of half finished sentences, often containing mathematical operations but never related specifically to the problem. For example:

L. *"times by six because there are six faces."*
G. *"No, that's not going to work."*
L. *"Oh yes, we're doubling up on those again."*

The part where an observer finds out what L is suggesting "you times by six" is not missed out; it is not there. However G seems to be aware of what was being suggested. They reach a consensus about many things by using this implicit type of conversation. They seem not to need to use specific nouns to communicate ideas between one another. The verbalisations are transient, sometimes seeming to change to a different idea as the speaker is talking. From the way the conversation goes, the members of the group generally appear to keep up with one another's ideas without the references being any clearer to the 'outsider' who does not share their understanding. They seem to share a knowledge of what the others are thinking about. Christine is very left out at this point, as the conversation is impossible to follow without "insider" knowledge. When asked for clarification the students were unable to provide it.

They seem unable to use specific terminology to express their mathematical conclusions. Is it that they have never picked up the proper use of "faces," "edges" and "corners" in relation to a cube, or are they unwilling in this group situation, to use words which others are not using? These words are metaphorical in origin and not part of their ordinary conversational spoken language. They produce a first draft of a written report after about an hour of discussion. The first draft is submitted to Christine, who reads it through and asks for clarification of some of the wording. The algebra contained in this first draft is well formulated. It is the explanation of their algebraic generalisations which is ambiguous. The clarification given to Christine by the students, involved a lot of pointing at diagrams on the papers they are working on. They accepted the need to produce a better draft. The second written draft proves to be a lot more difficult to write than they envisage and despite a lot of discussion, they never pin down exactly what they want to say. In the words of one student, *"I know what we're doing, I know why we're doing it but I don't know how to explain it."*

The research indicated a reluctance on the part of students to use subject specialist terminology. They seemed afraid to use non-familiar terms, especially in front of a teacher. In fact, they avoided using even the simplest mathematical vocabulary, preferring to refer to "things" and "it," rather than specific terms. The vocabulary they

did use, had been introduced in Years 7 and 8, seeming to indicate a lack of progression and development of use of subject terminology, or demonstrating the length of time it took to become comfortable with these terms.

The written outcomes of the investigation were not well structured; there was no cogent argument or explication. The students wrote in note-form, related to the diagram and text model in the textbooks they were familiar with. The writing at this stage did not convey a coherent, or sequential explanation of the mathematical problem and their conclusions.

Students seemed surprised and not able to understand why Christine could not follow the logic of their written explanation. She had watched and on some occasions joined in the development of their thinking about the problem but the students appeared to be unaware how little literal sense their words made out of context and as an English teacher that is what she was looking for. They did not seem to be considering the wording of their explanation. They were primarily concerned with completing the task, rather than clarifying and developing their ideas. Transferring their ideas from spoken to written form presented problems. They found it difficult to find words which would express their shared visual and spoken understanding. The students claimed that they knew what they wanted to say but could not put it into words. Clare was frustrated by their inability to use subject terminology and Christine was frustrated by their inability to communicate meaning.

Clare had encouraged the students in their lessons to experiment with using language to express mathematical ideas in order to develop their confidence and expertise. However, broader research undertaken by Christine, in language and learning across the curriculum, indicated that their use of terminology may be inhibited by other teachers' expectations.

Teachers across the curriculum varied in their expectations of students writing. Students were faced with different expectations from subject teachers. The form the writing had to take for example in writing an essay varied from subject to subject, as did the emphasis on different aspects of writing. The emphasis could be on neatness of handwriting or accuracy of spelling, punctuation and grammar.

Writing was used most often in copying from the board or a textbook. There was little evidence of its use as part of a formulating process, or for articulating ideas. If redrafting took place the emphasis would be on tidying up the handwriting, spelling etc. and not on developing and extending ideas. The idea of using writing as a medium to formulate hypotheses, develop and extend a line of argument was very rarely found. Teachers in some subjects required a high degree of spoken and written accuracy in the use of subject specific terminology, without developing feelings of ownership or confidence in its use. The lack of emphasis on students' own use of language may be a possible explanation for students' inability to use the language of the subject to make sense of their understanding.

The purpose of redrafting is a complex issue. From Christine's wider investigations it seems that teachers and students in some subjects understand re-drafting to imply simply copying up a rough draft neatly, having corrected spelling and punctuation mistakes. There is little awareness of the wider implications of re-drafting i.e. requiring students to

consider and reflect on the meaning and coherence of their written work. In mathematics, writing should be perceived as an integral part of the curriculum, used as a means of formulating and recording full explanations of each skill and concept as they are encountered. This is now standard practice in Clare's classroom. Here, every piece of writing is also a scrutinised writing, with neighbours being the initial and most common audience but also wider contexts used to encourage clarity in expression. This is following the standard experience in the English classroom in an attempt to provide a common demand on childrens writing to be clear and understandable in a range of contexts.

Conclusions

Our research has revealed the complexity and huge range of issues relating to the process of language and learning in both subject disciplines. There do appear to be principles underlying the teaching of mathematics, through the use of language. Students' understanding of mathematical concepts may be acquired through the common use of language skills such as:

Spoken discussion
Written explication
Questioning
Formulating hypotheses
Understanding terminology
Imagining and symbolic interpretation
Listening

All these are part of the English curriculum and indeed form part of all subject disciplines, since using language is fundamental to effective learning. It would seem that students' competence and confidence in studying mathematics, could be enhanced by greater proficiency in language skills. However, there may be insufficient awareness of the importance of the role of language in the construction of understanding in mathematics. The National Curriculum must bring greater interest in this issue as teachers of mathematics at all levels attempt to implement the demands of Attainment Target 1. How requiring younger children to discuss mathematical ideas will affect older students' competence in producing written records of their discoveries remains to be seen. There are reasons to hope.

Evidence is available to suggest that teachers may be restricting students' learning by their more formalised expectations of language use. The skills of using language for reasoning and justification must be developed progressively throughout a student's time at school. It must not be assumed that they will discover how to do this by themselves. Language use is not just a problem in mathematics; it is a whole school issue. Increased awareness and understanding of language and its significant role in learning should result in more effective teaching and learning across the curriculum.