This article describes part of an ongoing project with teachers from Year 0-13 in a Māori-immersion school in New Zealand. It discusses the process of identification of genres from samples of students' writing. Halliday's ideas about the relationship of the context of situation to the texts was the underlying theory for identifying the genres. Three genres were identified from over 2000 samples: description, explanation, and justification. As well a number of different mathematical writing modes were also identified. There appears to be a relationship between the purpose of the writing, the audience and the mathematical writing modes employed.
GENRES IN THE MATHEMATICAL WRITING OF MÄORI-IMMERSION STUDENTS

Tamsin Meaney, Uenuku Fairhall, Tony Trinick

Charles Sturt University, Kura o te Koutu, University of Auckland

This paper describes part of an ongoing project with teachers from Year 0-13 in a Mäori-immersion school in New Zealand. It discusses the process of identification of genres from samples of students’ writing. Halliday’s ideas about the relationship of the context of situation to the texts was the underlying theory for identifying the genres. Three genres were identified from over 2000 samples: description; explanation and justification. As well a number of different mathematical writing modes were also identified. There appears to be a relationship between the purpose of the writing, the audience and the mathematical writing modes employed.

INTRODUCTION

Since 2005, with ten teachers, from Year 0-13 of a Kura Kaupapa Mäori (Mäori-immersion school), we have been researching, issues around using te reo Mäori (the Mäori language) in the teaching of mathematics (Fairhall, Trinick & Meaney, 2007). In this kura, as in many others, the students are often second language learners of te reo Mäori, with English as their first language. As well, many of the teachers gained their teaching qualifications in programmes designed for teachers of native speakers of English. Consequently, we have investigated several language issues to gain insights into how to improve students’ learning.

The aim for the 2007 project was to describe the types of writing that students currently used at the kura so that we could explore ways to increase both the quality and the quantity at all year levels. Writing was taken to mean anything that was inscribed on paper and so included diagrams and graphs.

At a meeting in 2006 to set the parameters for this project, the teachers, in the secondary section, described their experiences of students not wanting to elaborate on their explanations but rather keeping them short, using simple language that they felt most comfortable with. Mathematical language was used only because students believed that teachers expected them to use it.

By developing a data base of students’ pieces of writing, it was anticipated that the teachers would be able to explore how the quality of mathematical writing could be improved. Therefore, it was important to classify the pieces
of writing in ways that made sense to the teachers and this was done by identifying the genres, using Halliday’s (Halliday and Hasan, 1985) ideas about language.

**WHAT ARE GENRES?**

A genre is a text type that fulfils a particular function within a communicative interaction and thus has some stable features. Any text whether oral or written is influenced by three components. These are: what is being discussed; who is involved in the text (producing it, or interpreting it); and the form of the communication (written, oral, gestures, etc). Michael Halliday described these as the field, tenor and mode (Halliday & Hasan, 1985). Changes to any of these will result in changes to the text that is produced.

If similar texts are continually produced to fulfil the same set of field, tenor and mode requirements, then their linguistic and other features become stabilised over time. For example, demographic data are commonly presented in graphs, especially if they are going in reports designed for statistically literate adults. However, the inclusion of features changes over time and so these features should not be considered as being rigid. As Unsworth (2001) wrote:

> [g]enres are not fixed and invariant. They identify classes of texts with particular characteristics in common …. Genres, as integral features of subject area learning and teaching then, should not be considered as straitjackets but as starting points (p. 127).

Stabilisation occurs as a result of “negotiation among and between community members” (Wallace & Ellerton, 2004, p. 8). With this stabilisation of features, sets of texts can be categorised as genres. To not structure the texts, that are responding to the same set of field, tenor and mode in the conventional way, can result in the meaning from the text being misinterpreted. It is, therefore, important that part of what students learn at school is how to write the genres that are used in particular content areas (Unsworth, 2001). Knowing about genres is not just knowing what features to include but also knowing how and when genres are useful. As Pimm and Wagner (2003) wrote “[m]uch of this work (e.g. Martin, 1989; Halliday and Martin, 1993) is also rooted in questions of school systems developing greater equity by means of students gaining access to linguistic-cultural capital” (p. 162). In this project, identifying the genres was a starting point for teachers in considering how to improve the quality and quantity of students’ mathematical writing.

In discussing genres, there is a need to distinguish them from registers (Wallace & Ellerton, 2004). Halliday described registers as “the semantic configurations that are typically associated with particular social contexts (defined in terms of field, tenor, and mode)” (Halliday & Hasan, 1985, p. 43). For example, if the mathematical genres include word sentences then they would use certain vocabulary and
grammatical expressions from the mathematics register. Aspects of the mathematical register would form some of the distinctive features of each mathematical genre.

MATHEMATICAL GENRES

Although genres have received significant attention since the 1980s, especially in Australia and United Kingdom (Unsworth, 2001), very little research has been done in regard to those typically found in mathematics classrooms. Like Morgan (1998), Marks and Mousley (1990) identified several genres that mathematicians would use and that, therefore, should be included in students’ repertoire of mathematical writing. These genres were: procedural; description; report; explanation; and exposition.

However, when they investigated the genres which were used in eleven classrooms (7 primary and 4 secondary), they found many instances of recounts, incorporating symbols and visual representations, but very few examples of other genres. Recounts described what a student had done during a mathematical activity and was generally expressed as a narrative. This would suggest that these students were not learning the conventions associated with mathematical writing because “mathematics cannot be narrative for it is structured around logical and not temporal relations” (Solomon & O’Neill, 1998, p. 217).

Although the purposes for writing are different for mathematicians than they are for students, by the time that students are in their final years of high school it could be expected that they would have the skills to produce a range of mathematical genres. Some genres or early versions of these genres should be present in all mathematics classrooms, including junior primary classrooms. We were interested in considering what genres the students at the kura were using and how these related to the those outlined by others, such as Marks and Mousley (1990). However, we anticipated that our genres would be different because our context was different to others as was our purpose for doing the classification.

WHAT WE DID AND WHAT WE FOUND

The investigation of the students’ pieces of writing was done by the teachers with two outside university researchers. At a meeting in March, 2007, the teachers in pairs classified samples of students’ writing into categories. The samples came from different ages of students and were from a range of topics and had mostly been collected at the end of 2006. The quality of the writing varied. Two pairs then shared their categories and decided on a joint set. Once the three groups of teachers had agreed on a set of categories, all the teachers had a more extensive discussion about the genres. It was apparent that the teachers grouped samples of writing that had the same function. First, they identified the primary purpose of each piece of writing and
then looked at the structure within each group. Three genres and an initial set of mathematical modes were identified.

It was important to our project to have appropriate labels for the genres we identified. The genres were chosen because they fulfilled different functions. One was to describe, the next to explain and the final one was to justify. There was considerable discussion about labels at the March, 2007 meeting. The labels were: whakaahua (descriptions); whakamārama (explanation); and parahau (justification).

Although these categories were broader than those used by others (Marks and Mousley, 1990), it was still difficult at times to decide which of these genres a piece of writing belonged to. If the piece of writing contained more than one genre, it was decided to always categorise it at the higher level. For example, a piece of writing could begin by describing something but finish by explaining something else. However, both parts contributed to the meaning being expressed and could not be separated. An example of this can be seen in Figure 1. This student began by using symbols to describe the various combinations that different numbers and colours of blocks could form. She ended by providing an explanation of the equation needed to determine the number of combinations from the number of blocks and the number of colours. It was classified as an explanation.

![Figure 1: ECKaL3 showing a combination of description and explanation](image)

Although the genres identified at this meeting did not change, there were changes to the number of mathematics modes as more pieces of writing were added to the data.
The initial mathematical modes of writing were: pictures, iconic representations, graphs, geometric representations, symbols and narratives.

Other researchers had sometimes considered what we had labelled as modes to be genres. Solomon and O’Neill (1998) stated that “[i]n so far as genre shapes and constrains the nature of a text, then graphs, equations, proofs and algorithms can be considered as expressions of genre” (p. 217-218). However, our definition of genre was based on the function that it performed and therefore the channel through which the function is delivered was considered to be the mathematical writing mode. Ben-Chaim, Lappan and Houang (1989) described three modes that were used by students to describe an object made from cubes taped together. These modes were: verbal; graphic; and mixed mode. The verbal mode occurred when the student’s message was carried by words. A diagram could accompany the words but would not add any more meaning to what was stated in words. A graphic mode used diagrams with at the most labels to accompany it. A mixed mode used both diagrams and words to convey meaning.

Although in Ben-Chaim et al.’s (1989) study, the graphic mode was believed to be the more successful at accurately conveying information about the object, the teachers felt that commonly genres require a combination of modes rather than being exclusively one or the other. This belief is supported by O’Halloran (200) who wrote:

Mathematics is not construed solely through linguistic means. Rather, mathematics is construed through the use of the semiotic resources of mathematical symbolism, visual display in the form of graphs and diagrams, and language. In both written mathematical texts and classroom discourse, these codes alternate as the primary resource for meaning, and also interact with each other to construct meaning. Thus, the analysis of “mathematical language” must be undertaken within the context in which it occurs; that is, in relation to its codeployment with mathematical symbolism and visual display. (p. 360)

Over the course of 2007, more than 2000 pieces of writing were collected. All writing samples were scanned, classified according to genre and mathematical mode and then named and filed in the database.

There are still limitations with the data base and it remains incomplete. The junior section of the kura runs a two year cycle for their mathematics programme and so not all strands and topics were covered in 2007. In the secondary part of the kura, the teachers taught multiple mathematics classes. For this project each teacher focused on only one of their classes. Consequently, few samples were collected from Year 9, 10, 12 and 13. As well, the primary researcher who collected the pieces of writing did so during her once-a-term visits to the kura. During these visits, pieces of work were not always collected from the teachers, sometimes because a teacher was away or because writing had been part of classroom displays that were no longer available when the researcher visited. However, the data base is quite extensive and does show a range of writing done in mathematics classrooms.
WHAKAAHUA

Whakaahua was the label given to pieces of writing that described something. Marks and Mousley (1990) separated descriptions from reports but Whakaahua contained both (there were in fact few reports in our sample). Wallace and Ellerton (2004) stated that “[d]escription and report genres provide the nature of individual things and the nature of classes of things, respectively” (p. 9).

Whakaahua provided opportunities for students to learn the conventions of mathematical writing. Descriptions used the greatest range of mathematical writing modes and this can be seen in Table 1.

As more samples were collected and added into our classification system, it became clear that a defining characteristic of Whakaahua was the way that new information was added. In Halliday’s Systemic Functional grammar, the way that new information is juxtaposed with given information is important in the construction of meanings in texts (Unsworth, 2000). If the addition of new information was cumulative (this is a triangle, it has three sides and it has three angles), or if new information could not be added without changing the function, then the piece of writing was classified as Whakaahua. Thus, equations such as $3+4=7$ could be classified as a description. Adding new information, such as $(3\times1)+(2\times2)=9-2$, changes the function of the equation from merely describing a simple fact to explaining how a set of related terms can be described. It is the combination of these descriptions that shows a deeper level relationship between numbers.

Table 1: Mathematical modes used in different genres.

<table>
<thead>
<tr>
<th>Genres</th>
<th>Mathematical writing modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whakaahua</td>
<td>- Combination (DC)</td>
</tr>
<tr>
<td></td>
<td>- Geometry: Angles (DGA); Lines (DGL); 2D shapes (DG2D);</td>
</tr>
<tr>
<td></td>
<td>Rectangles (DGR); Squares (DGS); Triangles (DGT);</td>
</tr>
<tr>
<td></td>
<td>3D shapes (DG3D); Cubes (DGC); Rectangle Prism (DGRp);</td>
</tr>
<tr>
<td></td>
<td>Square Pyramid (DGP); Tetrahedra (DGTe);</td>
</tr>
<tr>
<td></td>
<td>Triangular Prism (DGTP)</td>
</tr>
<tr>
<td></td>
<td>Tech Drawing (DGTD)</td>
</tr>
<tr>
<td></td>
<td>Transformations - Combined (DGTrC);</td>
</tr>
<tr>
<td></td>
<td>Enlargements (DGTrE);</td>
</tr>
<tr>
<td></td>
<td>Reflection (DGTrRe)</td>
</tr>
<tr>
<td></td>
<td>Rotation (DGTrRo)</td>
</tr>
<tr>
<td></td>
<td>Translation (DGTrT)</td>
</tr>
<tr>
<td></td>
<td>- Graphs: Cartesian (DGrC); Relations (DGrR); Statistics (DGrS)</td>
</tr>
</tbody>
</table>
- Iconic Diagrams: Clock Face (Time) (DICF); Iconic (DII)
- Narrative (DN)
- Patterns: Combined (DPC); Iconic (DPI); Symbolic (DPS)
- Symbols: Algebra (DSA); Decimals (DSD); Fractions (DSF); Integers (DSI); Whole Numbers (DSWN)
- Tallies

**Whakamārama**
- Combination (EC)
- Geometric (EG): Transformations - Combinations (EGTrC) - Reflections (EGTrRe) - Translations (EGTrT)
- Narrative (EN)
  – Symbolic (ES)

**Parahau**
– Combination (JC)
- Narrative (JN)

**WHAKAMĀRAMA**
Whakamārama or explanations use a series of steps to illustrate how something came to be and often appeared when mathematics was employed to solve problems. As well, narratives about how to turn a net into a 3-dimensional shape as well as multi-step equations were classified as whakamārama. Marks and Mousley (1990) would have described this genre as procedural. However, procedures have a sense of involving a lock-step process. For example, from earlier research on genres, Unsworth (2001) described the stages in a procedural text as: goal; materials; steps (p. 123). The pieces of writing that we identified as whakamārama certainly explained how something had been done but did not always provide the steps in a set order. An example of such a piece of writing can be seen in Figure 2.
Figure 2: ECUnL5 showing an explanation provided in a non-lockstep manner

PARAHAU

Over the course of the project, very few Parahau or justifications were collected. However these were considered pieces of writing whose primary purpose was to provide information about why something was done. These pieces of writing were more reflective as students had to evaluate what options there were and to discuss why they chose a particular one to use. An example is given in Figure 3.

All genres included a range of different modes. However, whakamārama and parahau were more likely to use a combination of modes in the one piece of writing. In the samples that we collected, there were very few justifications that did not use a combination of diagrams, words and/or symbols. In the junior classes where justifications were just beginning to be taught, sometimes these were just narratives. More often, justifications contained a combination of modes as can be seen in Figure 3.
THE RELATIONSHIP BETWEEN FIELD, TENOR AND MODE AND THE THREE GENRES

Given that the genre was based on the purpose for writing, it was the reflection of the field of the context of situation. However, it was also common to find that there were particular audiences and modes that accompanied the fields for particular genres.

At the meeting in March, 2007, the teachers discussed how different audiences would have an impact on the writing. Sometimes the writing would be exclusively for the student and conveyed limited if any meaning to others. This would be because of what Wallace and Ellerton (2004) described as “semantic discontinuity” whereby the reader must fill in the gaps between the evidence and the conclusions to make sense of what had been written. However, the teachers at the kura felt that most writing done in mathematics classes was done for the teacher so that they could assess the students’ learning. As well, students would produce mathematical writing in exams for examiners who they would never meet. Other audiences may be other students or parents or community members.

Figure 4 is one representation of how the relationship between field, tenor and mode could be perceived. Whakaahua describe mathematical objects or facts and are complex only of a lot of detail is added. Writing whakaahua involves students in learning mathematical writing conventions. At the very beginning levels of school, this involves learning how to form the numbers or shapes. At later stages, students learn the appropriate way to write a number sentence or produce a graph. Whakaahua fit into what Unsworth (2001) described as recognition literacy in that they support the “learning to recognize and produce the verbal, visual and electronic codes that are used to construct and communicate meaning” (p.14). Without this literacy knowledge, whakamārama and parahau cannot be produced. However, where Figure 4 is different to the ideas of Unsworth is that he links recognition literacy to common experiences of everyday life whereas in mathematics classroom, descriptions are very closely aligned with students using the mathematics register. Whakamārama is about explaining a mathematical event or phenomena, and thus is about using mathematics and recording what is done. Parahau, on the other hand, is about explaining why something has been done in particular manner and involves reflection about what was done and why. Consequently, writing becomes part of the learning process in a much more conscious way than it is with whakaahau and whakamārama.
Figure 4: The context of situation for the use of the three genres of mathematical writing.

The model in Figure 4 should not be seen as fixed. The field, tenor and mode are not always combined in this way for each of the genres. Of the different parts of the model, the connections of the different tenors to the genres is the most contentious. Whakaahua and parahau can be written for others. Figure 5 provides an example of a description that was written for public display. Nevertheless, it did seem that in our writing samples, whakaahau were mostly produced for the teacher as part of the learning about the conventions of mathematics writing, whilst whakamārama were mostly produced so that others, including the teacher, could follow the logic of what was done. Parahau even when produced to fulfil requirements of the teacher forces a student to do some self-reflection. Therefore, Figure 4 should be considered as one interpretation of the relationship between field, tenor and mode of writing done in mathematics classrooms. It is, however, better to be considered a common combination rather than the only interpretation of how the field, tenor and mode are related in each genre.
References


