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Secondary school teachers' knowledge of the dynamics of teaching and learning mathematics in multilingual classrooms

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multilingual South Africa and our eleven official languages, nine of which are African languages. Nevertheless research on English-speaking teachers who do have an additional African language would illuminate whether such teachers with their plurality of languages significantly impact on communication and hence mathematical activity and learning in their multilingual classrooms.

As Helen provocatively suggests:

> being a bilingual student of mathematics is not in itself a determining disadvantage. In the context of South Africa, where the norm is to be bilingual, we could be researching the negative effects on students of monolingual teachers. Instead, we research the disadvantages for mathematics performance lying in the student. In a time of reconstruction in South Africa, we must develop strategies for the mathematics classroom that maximise the possibilities for the bilingual student to develop to her fullest potential.
>
> (Rademeyer, 1994, p. 142)

It is hoped that in its theoretical contributions, its implications for teacher education and recommendations for further research, this thesis offers generative possibilities in the field of mathematics education.

explored partly because of the sequencing of data gathering and layered data analysis, and also because of the focus and scope of the study. Time, in particular, emerged as a significant additional dimension requiring further research. Four of the teachers talked about time constraints in their initial interviews (see Appendix C). Teachers' decisions and reflections are indeed constrained by the time-space relations in school classrooms. Helen worried about 'going on too long'; Thandi worried that if she has to work continually in more than one language, this will take time; and Sue's reflections include a concern that one of her whole-class discussions was worthwhile, but perhaps not in relation to the amount of time she gave it. These issues were not taken further in this study. Clearly, time is a significant fourth dimension of the dynamics of teaching and learning mathematics in multilingual classrooms and should thus be factored in to any further study in mathematics and language in school.

Finally, this study worked with language-in-use (culture) and analysed classroom data as they related to teachers' reflections and as they illuminated teachers' dilemmas within the three-dimensional dynamic in multilingual classrooms. A linguistically-focused analysis of the classroom transcripts will undoubtedly throw additional and different light onto the complexities of teaching and learning in multilingual mathematics classrooms. However, as shown in Chapter 1, mathematical limitations can result from a linguistically focused study. Further study of multilingual mathematics classrooms, of the relationship between mathematics, education and language could well be enriched by an interdisciplinary team where mathematics educators and sociolinguists combine their respective skills and insights.

In closing, the analysis and discussion of code-switching in this study has focused on teachers and pupils whose main language is not English, but who are teaching and learning in English. Would there be teaching and learning benefits in South Africa if English-speaking teachers could speak a vernacular African language? Of course, knowledge of one African language does not fully confront the reality of

in Sue's practice constrained mathematical knowledge development motivates ethnographic study of participatory-inquiry approaches. I located Sue's dilemmas of mediation within the broader democracy-development tension. It is in Sue's classroom, where participation and diversity are encouraged and enabled, that possibilities for deepening mathematical knowledge are created, and then partially lost. Through further research we need to develop our understanding of teaching and learning mathematics in school by building on and learning from the possibilities and constraints in participatory-inquiry multilingual classrooms such as Sue's.

Questions that arose and could not be answered are probably a consequence of the sequencing in this study. All data gathering preceded in-depth, layered data analysis. Thus some of the issues identified in the analysis of the initial interview were not explored in the reflective interviews nor workshops. For example, in the initial interviews three teachers pointed to instances of communication breakdown that they felt were intuitively part of their multilingual context. I called these dilemmas of explanation and explained that the teachers could not easily describe nor ascribe these incidents. Further research, through situated teacher stories (Clandinin and Connelly, 1996) would provide insight into instances of communication breakdown and thus potentially contribute to reducing communication breakdown and/or enhancing teachers' capabilities in recognising and using such instances productively and constructively in their practice.

In particular, the silence on communication breakdown in ex-DET schools raised the question of whether the homogeneity assumed in these classrooms was appropriate. Like any classroom, classrooms of African learners are also heterogeneous. Further study on communication within seemingly homogeneous all African secondary mathematics classrooms is needed.

Other dimensions of the dynamics of teaching and learning mathematics in multilingual mathematics classrooms that emerged from the study could not be

As with all research, a specific methodological approach is as likely to leave some questions unanswered leading to the need for further research. A crucial advantage of the methodological choice of working across three multilingual contexts rather than ethnographically within one such context was the identification of presences and silences across teachers in different contexts and hence empirical support for a conceptualisation of teachers' knowledge as personal, practical and situated. This methodological choice now points to specific focuses for further research in each of the three different multilingual contexts analysed.

Emerging from the exploration of code-switching is the need for research into the tacit practice of modelling mathematical English in multilingual classrooms, especially in classrooms where neither learners nor the teacher have English as their main language. An ethnographic study of such classrooms could illuminate the purposes and effects of such practices for both teacher and learners. Furthermore, the management of code-switching in task-based multilingual secondary mathematics classrooms requires further study.

In the more obvious multilingual classrooms of the Model C schools in South Africa, the actual effects of explicit language teaching, of language being used as a public resource for teaching needs further study. Specifically, the following question needs to be answered: to what extent and how does explicit attention to pronunciation on the one hand, and to formal mathematical expression on the other provide smoother access to mathematical practices? Moreover, a further question that remains unanswered is whether the practice of, and a concern with, explicit mathematics language teaching is exaggerated in multilingual classrooms.

This study has argued that a participatory-inquiry approach creates a qualitatively different learning environment from dominant traditional teacher-centred environments. Sue's approach creates a mathematically rich environment where tensions in the teaching-learning dialectic are clearly revealed. That an instance

S: *... There are some kids who are really not good at explaining themselves, and I don't do anything to address that ... maybe what I am saying is that there is a purpose to being in the classroom and that is to learn and I am there to guide learning. So it is not good enough for all of us to say how we feel. We've got to go somewhere with that and I am not sure how to do that.*

(II6, 1165-1178)

As is the case in any moment of educational reform, teachers in transitional South Africa face a proliferation of official policy documents that effect their work. There are now national norms and standards for teacher education (COTEP, 1996), two government White Papers on Education and Training (DoE, 1995; 1996), guidelines for a National Qualifications Framework (Lifelong Learning, 1996) and a National Teacher Education Audit (Hofmeyr and Hall, 1996).

In all this policy documentation is the realisation that a commitment to learner centredness and to multilingual teaching and learning lies in the recognition of teachers as key to any improvements and change in the quality of learning in schools and other educational institutions. But, as discussed in Chapter 1, the road from policy to successful implementation is long and complex. In the policy documents there are elaborations of how to develop two languages in the curriculum for all learners, and of qualification requirements that teachers study two languages in their preparation to teach. There is also explicit encouragement for teachers to adopt multilingual practices. But there is no guidance and understanding of how to develop *subject* knowledge using all languages in the class as a resource for learning. Hence the recommendations in this thesis that reflecting on teachers' actions in a range of multilingual contexts as part of an interacting three-dimensional dynamic should be encouraged in official policy. Such activity should indeed become part of teacher preparation and development programmes.

both their contexts and their biography, of the social and the political, the personal and the practical. For Thandi, the dilemma of code-switching is tied up with her own ability to switch, her political aspirations for her pupils and her view of mathematics. Sue's strong conviction emphasises participatory and meaningful learning, and for Helen mathematical expression is a sign of mathematical competence and skill. Hence, Helen's emphasis and then doubts about explicit mathematics language teaching, and Sue's concerns about meaning negotiation through pupil-pupil discussion, and about how to 'develop their language'. Managing dilemmas also intersects with broader social and political factors such as the status of English as the language of power in South Africa and the rhetoric of democratic educational practice that wove through progressive educational circles from the late 1980s.

The implications of the findings in this study for teacher education are profound yet simple. A programme in teacher education would be enriched by documented cases that highlight dilemmas teachers face, the kinds of snapshots provided in the vignettes in this study. A language of dilemmas can also assist teachers to recognise, talk about and act on the tensions in their practice. Such engagement could empower teachers to make informed and contextually appropriate decisions to maximise learning possibilities for their diverse learners.

Teaching dilemmas, despite their expression as binary opposites, are useful in teacher education precisely because they highlight fundamental pedagogic tensions that cannot be resolved once and for all. They are potential sources of praxis. They can be managed, and awareness of them can lead to transformatory practice.

The teachers in this study reveal there is no simple route to effective high quality mathematics teaching and learning in complex classrooms. Learning about teaching involves enabling teachers to be appropriately discerning at critical moments, to help Sue move on from a poignant comment in her initial interview:

The *dilemma of transparency* (of the visibility vs. invisibility of language in the process of mathematical classroom activity) is highlighted in classrooms where the racial composition of the pupil body changed rapidly and so too its multilingual character. Teachers in these classrooms advocated the benefits of explicit mathematical language teaching, and not only for learners whose main language is not the language of instruction. Yet episodes in Helen's classroom revealed that attempts to harness language as a public resource by explicitly focusing on its form, can inadvertently obscure rather than provide smooth entry into mathematics. It is not simply a matter of 'going on too long' or talking too much, but of managing to shift focus between mathematical language and the mathematical problem at play, of managing both implicit and explicit practices (and of course these are intertwined).

Together, the vignettes in Sue's and Helen's classrooms reveal the fundamental tension between implicit and explicit practices with respect to language issues in multilingual mathematics classrooms. As has been argued, these issues are present in all classrooms, but are present in particularly heightened form in multilingual classrooms.

Each of the three key dilemmas and their extended forms were constantly analysed within a conception of a multilingual mathematics classroom as dynamic and three-dimensional. For example, dilemmas around access to English emerge in practice in an ongoing and dynamic relationship with access to mathematical discourse as well as access to classroom cultural processes. In the logic of practice, it is sometimes difficult for teachers to see how classroom cultural processes, such as a participatory-inquiry approach, factor into classroom interactions and the quality of mathematical activity and mathematical meaning making.

Moreover, through three distinct vignettes on how teachers in multilingual mathematics classrooms face and work with dilemmas in their teaching, this study has shown that the dilemmas emphasised by particu' teachers are a function of

(6) cultural context (classroom + problems to solve)

Can you recall a classroom incident / incidents that illustrate these issues?

14. How did you come to identify these issues?

15. Why do you think these are/have become issues?

16. How do you try to address these issues?

17. Have you discussed these issues with colleagues? In your school? Elsewhere?

18. Turning back to our earlier discussion on mathematics teaching in general at this level, how would you relate the language issues you have described to teaching in general?

    Prompt: does it deserve special attention? Why? why not?
    is 'SECOND LANGUAGE' a problem?

19. What ideals abandoned? ie tried and unsuccessful?

20. Have you ever observed another teacher teaching?
    Yourself teaching? How do you feel about a process that will involve others (at least me) reflecting with you on your teaching.

21. Report back - seminar/discussion

8. You know that this research is about language. Putting that focus aside for the moment, lets talk first more generally about teaching mathematics (at the junior secondary level) at your school. You have had .... years experience.

9. What do you consider to be the most important tasks and challenges for you teaching mathematics at this level in your school?
Prompts (1) skills? understanding? relevance? meaning:
(2) why are these most important
(3) what strategies? how

Can you give examples to illustrate these points?

10. What, for you, are the greatest problems you have to deal with teaching mathematics at this level?

Prompts (1) conditions
(2) attitudes / fear
(3) diversity (ability? culture? language? history?)
(4) time
(5) syllabus
(6) contextualising / meaninglessness

Again: probe why and how

11. What, for you, are the rewards, the things that work and work well?

12. Describe, briefly, a typical lesson with this specific class. What do you do? The pupils do? The materials you use? (Paint me a picture)

Turning now to focus on language and mathematics learning: You have already said that ..... I am interested in trying to piece together what teachers experience and identify as issues.

13. What do you find to be language-related issues that arise in your teaching and pupils' learning?

Prompts: (1) communication (pupil-teacher; pupil-pupil)
(2) terminology
(3) symbolism and formal maths language
(4) text books and e.g. word problems
(5) translation

6. CURRENT TEACHING POST / RESPONSIBILITIES / CLASSES

.....
.....
.....

BIOGRAPHICAL DETAILS: PUPILS

7. JUNIOR SECONDARY CLASS FOR FOCUS:

LEVEL: .....

NO OF PUPILS: .....

BOYS:.... GIRLS: .....
MAIN LANGUAGES: .....
.....
.....

AVE AGE: ....

COMMENTS ON CLASS: .....

DESCRIPTION: SCHOOL

8. LOCATION OF SCHOOL .....
.....

PRIVATE/STATE .....

FEES/BURSARIES .....

EXTENT OF RACIAL INTEGRATION .....

ETHOS..... .....
.....
.....

ANY OTHER DESCRIPTIVE INFORMATION?
(eg conditions?).....
.....
.....
.....

APPENDIX A

INTERVIEW SCHEDULE:

BIOGRAPHICAL INFORMATION TEACHER

1. NAME: .....

2. SCHOOL: .....

3. ACADEMIC QUALIFICATIONS (WHEN AND WHERE)
.....
.....
.....

4. PROFESSIONAL EXPERIENCE: YEARS (NO).....

CLASSES.....

SUBJECTS.....

SCHOOLS.....

OTHER INSTITUTIONS.....

OTHER.....

5. COURSES/INSET ACTIVITY IN MATHS EDUCATION:.....

WHEN? .....
.....

WHERE?.....
.....

WHO?.....
.....
.....

WHAT?.....
.....
.....

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APPENDIX D

Partial video transcripts for each teacher, two of whom taught two classes on each day, are referred in the following chapters as follows:

VT1A = Video Transcript for Helen, Teacher 1, Lesson A. Wed 14 October;
VT1B = Video Transcript for Helen, Teacher 1, Lesson B. Fri 16 October;
VT1C = Video Transcript for Helen, Teacher 1, Lesson C i.e. lesson in following year on same class, but as part of Helen's action research for the workshops.
VT2A1 = Video Transcript for Sara, Teacher 2, Lesson A, class 1; Mon 19 October
VT2A2 = Video Transcript for Sara, Teacher 2, Lesson A, class 2; Mon 19 October
VT2B1 = Video Transcript for Sara, Teacher 2, Lesson B, class 1; Tues 20 October
VT2B2 = Video Transcript for Sara, Teacher 2, Lesson B, class 2; Tues 20 October
VT3A = Jabu, Lesson A, Tues 15 September
VT3B = Jabu, Lesson B, Wed 16 September

VT4A = Thandi, Lesson A, Tues 13 october
VT4B = Thandi, Lesson B, Thurs 15 October

VT5A = Clive, Lesson A, Mon 21 September
VT5B = Clivo, Lesson B, Tues 22 September

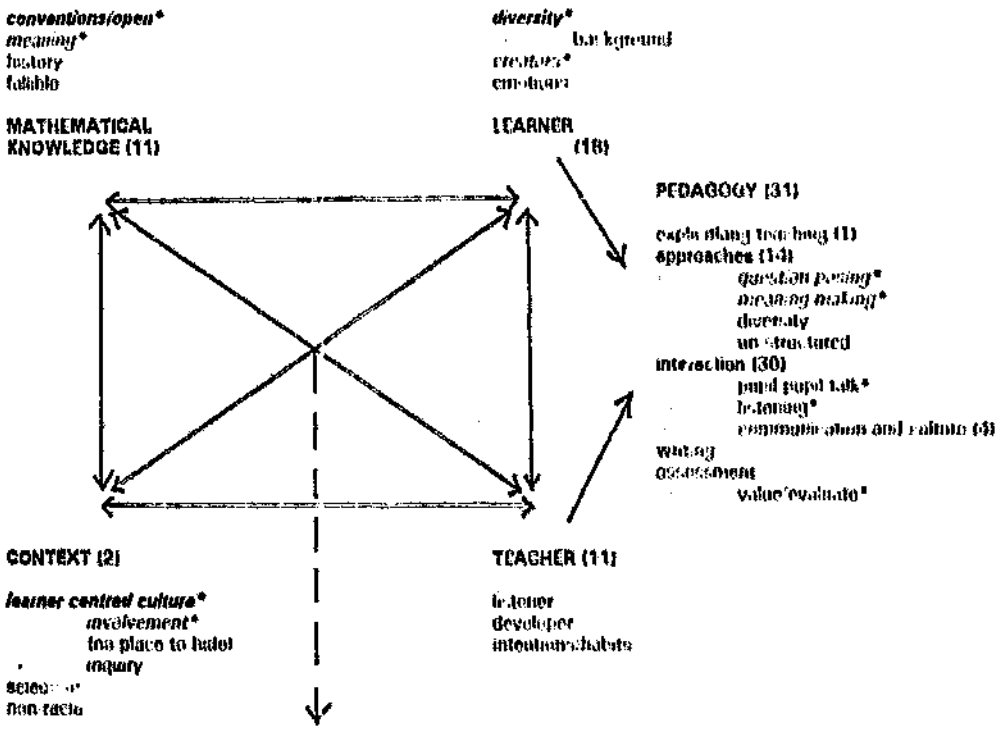
VT6A1 = Sue, Lesson A in class 1
VT6A2 = Sue, Lesson A in class 2, Thurs 17 September
VT6B1 = Sue, Lesson B in class 1
VT6B2 = Sue, Lesson B in class 2, Fri 18 September

References to video transcript in Chapters 5 - 7 will include lines of transcript.

Observational field notes were also taken. These are referred in Chapters 5 - 7 as follows:

VFN1A (Video Field Notes for teacher 1 lesson A
VFN2B2 (Video Field Notes for teacher 2 lesson B in class 2)

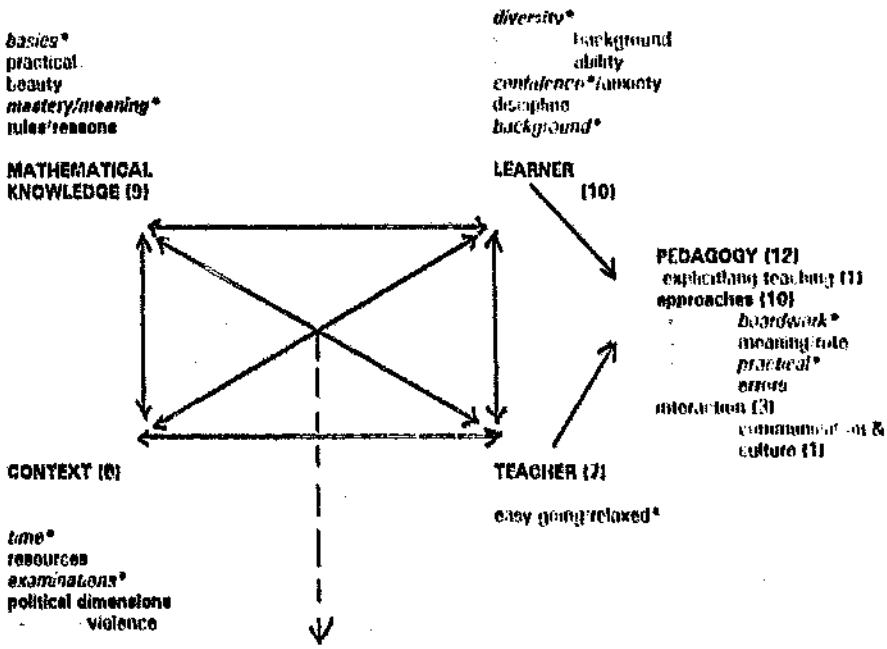
TEACHER G: SUE



LANGUAGE RELATED DILEMMAS

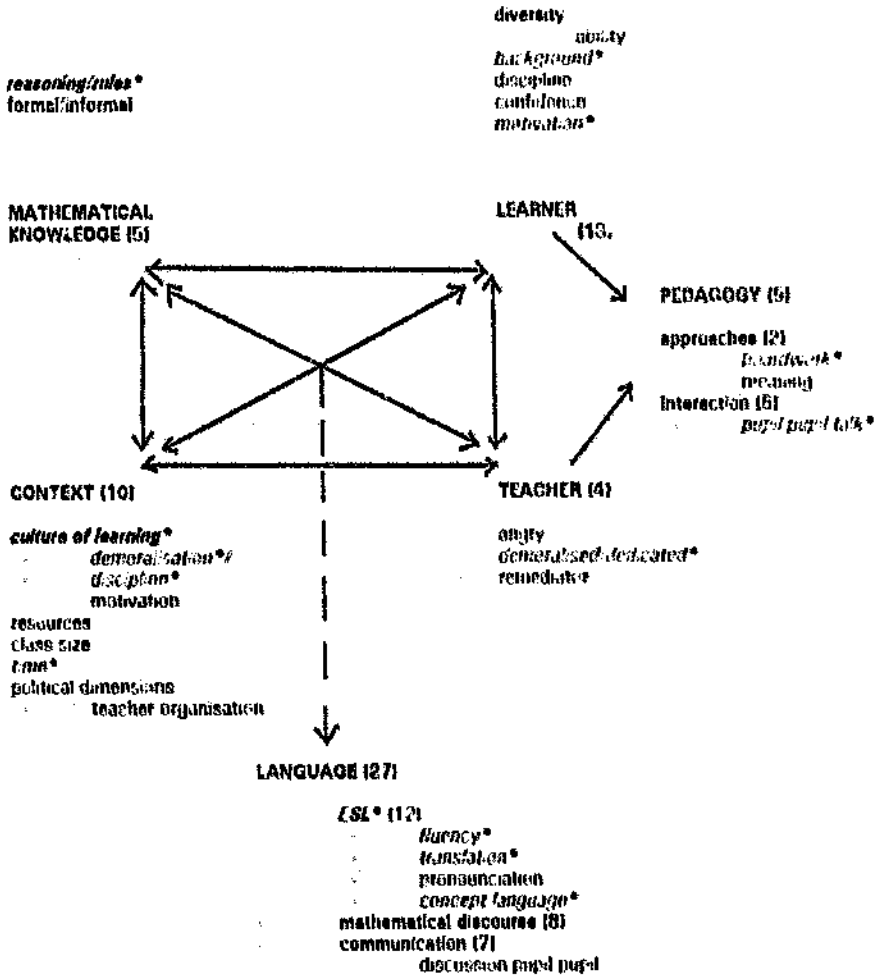
- listening, hearing/telling, developing English
- valuing/evaluating (good questions/discussion/explanation)
- structured/unstructured (explicit framing/open)
- having the language/having the concept
- having the language/having the culture

TEACHER 6: CLIVE



LANGUAGE RELATED DILEMMA
- having the language/having the concept

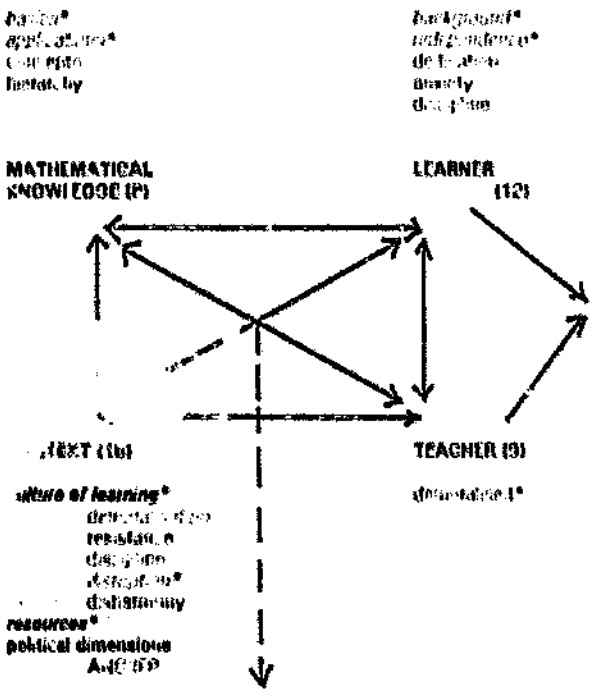
TEACHER 4: THANDI



LANGUAGE RELATED DILEMMAS

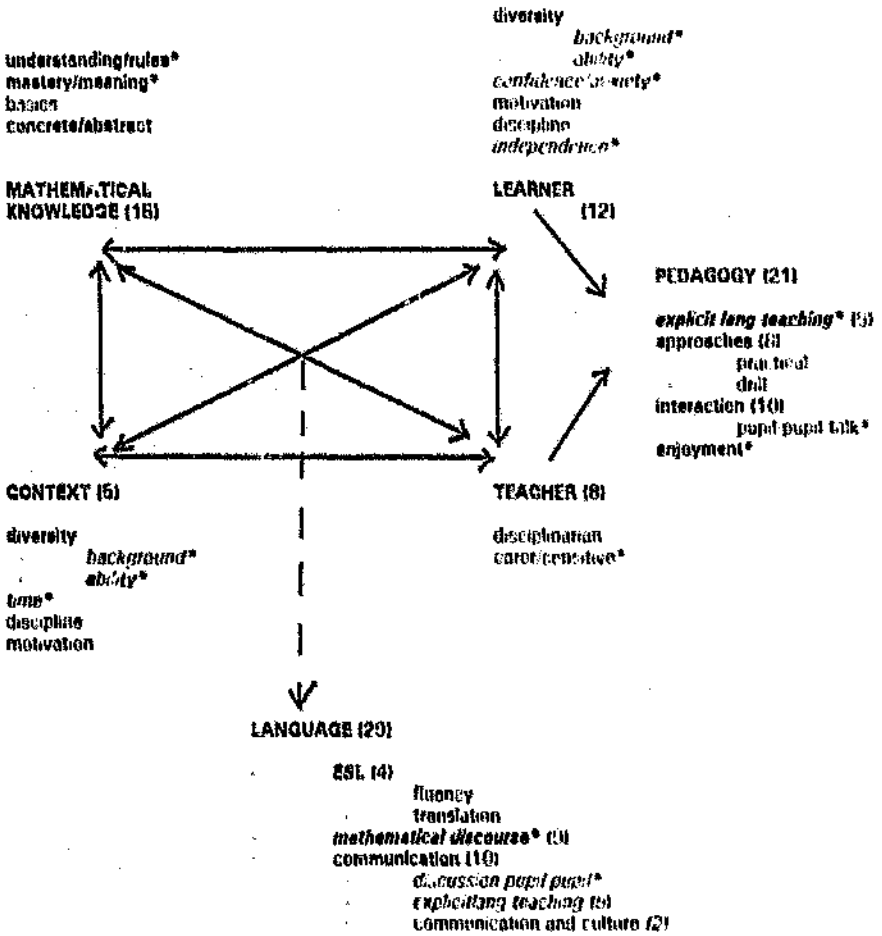
- **Tswana (vernacular)/English**
- **having the concept/having the language**

TEACHER 3 JABU



LANGUAGE RELATED DILEMMAS
having the concept/having the language (English)

TEACHER 2: SARA



LANGUAGE RELATED DILEMMAS

- exploratory talk/drill basic skills
- want more task-based learning/don't quite know what to do
- having the language/having the culture

APPENDIX C

TEACHER 1: HELEN

*maths as language**
concepts/skills/processes*
*application**
concrete/abstract
formal/informal*
history
mastery/meaning*
political dimensions
rule bound*

diversity
- ability
- *background**
- race

MATHEMATICAL KNOWLEDGE (9)

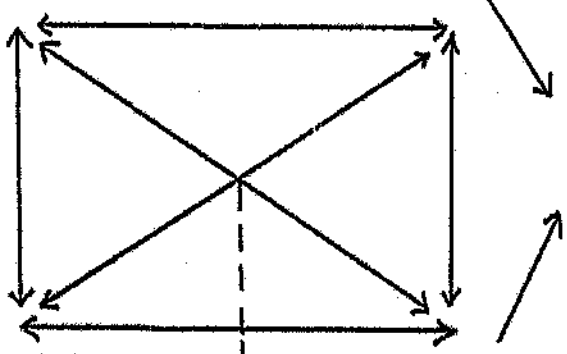
LEARNER (15)

PEDAGOGY (23)

explicit/ang teaching* (1)
approaches (12)
- *mirroring**
- *contextualising**
- imaging
- processes
- practical

interaction* (17)
- *pupil-pupil talk*
- *control*
- *ownership*
- *communication and culture (3)*

assessment* (6)



CONTEXT (4)

diversity*
- gender,class,race
- background
- ability

time*
political dimensions
- selection

TEACHER (4)

angry
political (gender, race)
insensitive
*control**

LANGUAGE (32)

- ESL (3)
- ***mathematical discourse* (9)***
  - transfer
- ***communication (16)***
  - discussion pupil-pupil
  - teacher-pupil
  - and culture (3)

LANGUAGE RELATED DILEMMAS
- explicit language teaching / meaning.
- discussion in vernacular/reporting in English
- develop mathematical English/put words in their mouths
- telling them what to say/hearing what they construed
- having the language/having the culture

3. Kids in lower classes cant express often their problem or question in English - need another pupil to help or let them ask in mother tongue - though translation a difficult issue NB they get the concept so let it happen in vernacular they expect more and more in vernacular (4)

English facility much less a problem higher up.

4. Mathematical language can be problem - special words simplify (many uses) ie instructions; distinguishing between factorise and divide - kinds of terminology; at least - different everyday use; negation; reversal; logical connectives; expressions - 'this subtracted with that'. (3)

5. Language issues in group work - (i) talk to each other in vernacular, then rely on one to explain, not all develop English; others don't regard this as problem - they need to talk so they get at the concept in whatever language; other if they talk in whatever lang then how will English develop - in general policy seems to be English should dominate
(ii) peer teaching is effective
(iii) they don't communicate on mathematics in groups easily with each other - don't listen, wont express themselves mathematically, play.
(iv) knowing what is good group discussion - what criteria - how should a std 7 or 6 be able to communicate?

6. Homework - cant ask for it (3) - in Std 7 - restricted to class time (resources eg text books issue + don't / will not do it and punishing doesn't help).
Interesting in town school - homework compulsory 2X week

7. Managing group work - time, class size, groupings, what is good discussion, finding good tasks.

6. STRATEGIES

MAJORITY RELATED TO COMMUNICATION IN THE CLASSROOM
- kids to write on board and EXPLAIN
- doing problems, examples, exercises in pairs or groups
- classroom discussion (teacher-pupils) when starting new work, encouraging responses and interaction, lively discussions and questions
- getting them to compare methods and answers

THEN (DEPENDING ON OTHER APPROACHES USED
investigative tasks
diaries
problem-solving
MAKING LANGUAGE EXPLICIT - ALL BENEFIT
trying to link different sections.

7. TYPICAL LESSONS

new section / introduction talk a lot
whole class teaching often - but with interaction
homework as part of lesson differs
identify main concept - think of misconceptions - worksheets
different yet quite similar

DIFFICULTY IN STD 7 AND LOWER OF GETTING PUPILS TO TALK EASILY IN ENGLISH - SEE BELOW

8. LANGUAGE

1. make language explicit - mixed schools - helps all
lots of repeating, re-explaining, making conventions explicit, restating in another way (English-speaking teachers) (4)

2. Getting pupils to verbalise /develop their maths language (4)

4. TASKS AND CHALLENGES

CONTENT - lay the foundations eg. algebra operations, angles (4)
- make meaningful; relate to everyday life; get them to make sense of answers - numeracy (3)

COGNITIVE - think mathematically, not just right and wrong, follow rules (2)

AFFECTIVE - love of subject, motivation, confidence, anxiety, attitudes, habits (past learning, worksheets, not learning) (6)

OTHER - difference between understanding and definition
- explicit language teaching
- transfer (knowledge to other area) and
- translate (to symbols)
- ask questions, learn from mistakes
- history and applications
- BALANCE between tool for life / life skills and going to Std 8
- qualifications of jun sec teachers often there on paper but not there in reality, colloges poor mathematically

5. PROBLEMS

overarching in township schools is breakdown of learning culture in pupils and culture of defiance in some teachers.

1. Background not in place - holes in knowledge (6)
INTERESTING THAT THIS WAS EXPRESSED BY ALL - CAN'T THUS ONLY BE PRIMARY PROBLEM! Some (smaller classes) cope more easily - time effects because of having to go back.

2. Lack of time to get through everything - for different reasons, a lot to do with resources. Inhibits more investigative activities (3).

3. Motivation (3), lack of interest - learning culture, not going on to Std 8 (3); shy / fearful.

4. Diverse backgrounds - mixed abilities (positive and negative (2) ; also gender and race practices can be problem (group work, interactions) (2)

5 Self-discipline and responsibility (wanting to be spoon fed + learning culture)

(private: troublesome, mixed ability, relatively poor English, mainly Soweto-based kids that travel, 30 kids)
(DET: loss of standards: mainly Tswana, breakdown of learning dominant, 42 kids)

REMAINING no longer teaching in Std 7
(X2) Can work with Std 7 teacher.

ACTIVITIES - an active interested group of teachers - further study, inset activity - teacher organisation / curriculum work of some kind.

3. **SCHOOL ETHOS / ATMOSPHERE / HOPES (emphases expressed)**

VERY VERY DIFFERENT:

* two stressed breakdown of learning culture
* both DET schools - breakdown of authority in school
  'Many teachers spend most of the time not going to class and no-one will confront them';

  'teachers no longer respect any authority - people do as they wish'

  'there is again an atmosphere to resist authority '... teachers included'

* despite all - some dedicated teachers in each of the schools, concerned to do the jobs of promoting learning - in two, working maths/science grouping of teachers.
* still striving for high standards

IN CONTRAST

* giving girls a sense of dignity and useful education, not overly competitive;
* academic excellence; brotherly love, rounded.
* student- centred, learner centred, encouraging questioning attitudes 'liberal values, middle-class values' - INVOLVEMENT - PARTICIPATION ETHOS, thus also high stress levels f[illegible] teachers - not necessarily for achievement but for involvement [illegible]iring minds.
* equal, good rounded education

given range and diversity, it will be interesting to explore further in each school if willing.
To see how you cope in different circumstances, not to judge

APPENDIX B

SUMMARY OF SOME POINTS FROM INTERVIEWS

1. RANGE OF SCHOOLS

* two large township schools - considerable overcrowding in all - and drawing kids from largely lower and some with mixed socio-economic homes - all limited resources, one outside main urban area; one serious difficulties because opposite a hostel.

* two private, predominantly black, one predominantly African, one much better resourced. Pupils from range of homes, fees low in one and bursaries in the other.
  Bridge year - to develop English

* two MC schools, one all girls 50% integrated, more than half qualify for subsidy; one co-ed, one outside main urban area, 25% integrated, middle class.
  One also has had bridging classes

Thus quite a range, in language terms, three teachers no African language - English only, classes multi-lingual.

2. TEACHERS

Past Wits students, preferably at B Ed/Hons level initial aim; problems! Teachers not range of schools, some not teaching, many not in jun sec - so drew in teachers no longer teaching in jun sec - also interested others. All some tertiary maths, most degrees in maths.

CLASSES

ALL TAUGHT FROM 6 OR 7 TO 10 - ALL TEACHING 9 OR 10 THIS YEAR

CLASSES FOR RESEARCH

2 x STD 6 (private + model c)
(private: 17 kids , few specific comments)
(model c: 33 kids, rowdy, range within 3 of 4 streamed classes)

2 x STD 7 (private + DET)

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