

Mathematics In Multilingual Classrooms: From Understanding the Problem to Exploring Possible Solutions

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The Journey 1998 – to date

- Where are **we** in the journey?
- What do **we** know?
- What is it that **we** still need to know?

What is the problem?

**Mathematics in
classrooms:**

problem

multilingual

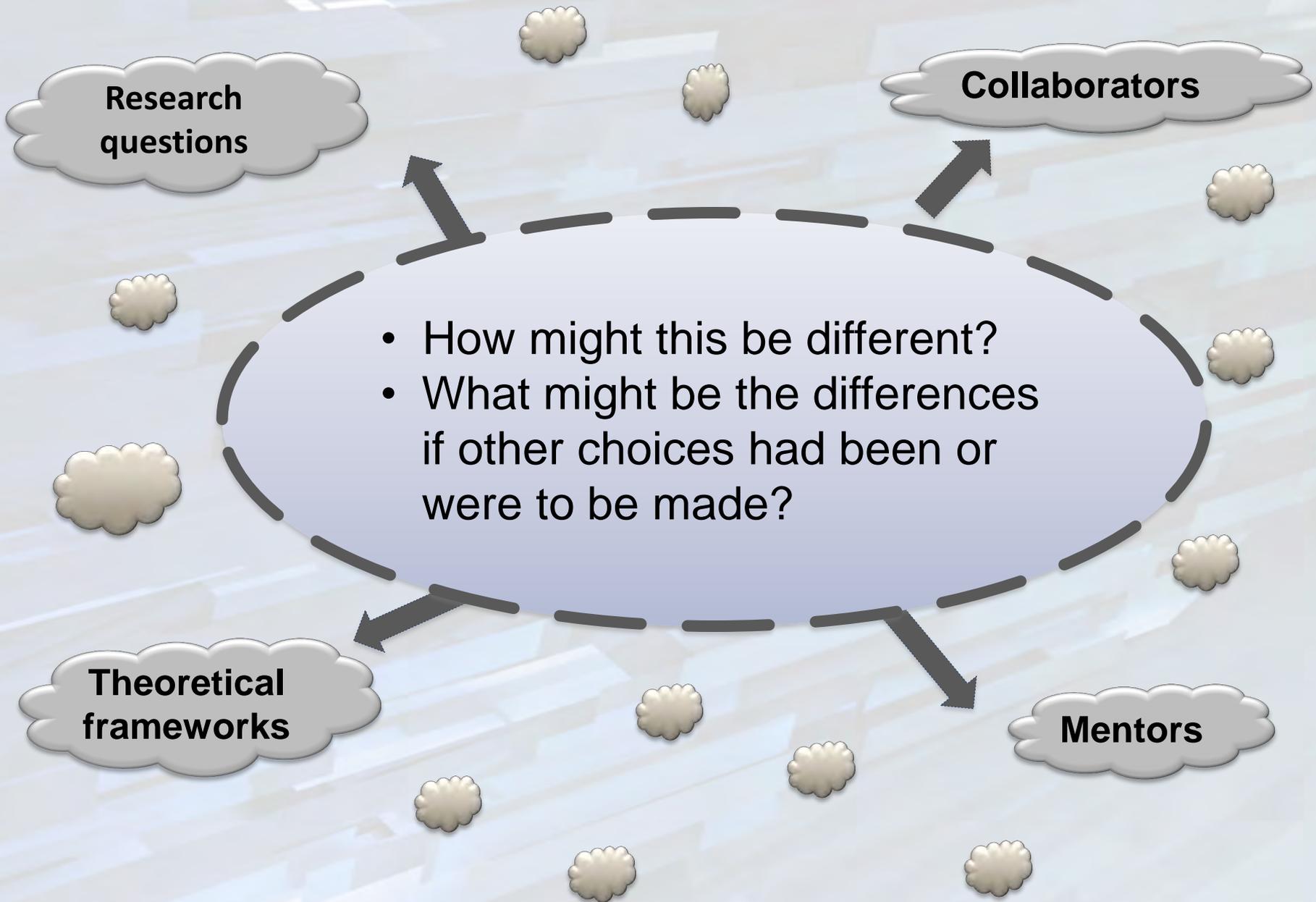
*from understanding the
to exploring possible*

solutions

Plural: There is not just one
solution to the problem!

The journey

- Is a personal story of my own exploration of possible solutions to the problem
- It is driven by questions within mathematics education that interest me
- It is influenced at **local** and **cultural** level by
 - Who I am
 - The communities I have participated in
 - Who I have worked with (mentors, students, collaborators), etc.



Some problems that have guided the journey

- Why is the performance of a majority of learners who learn mathematics in a language that is not their home language as low as it is?
- Why do teachers and learners in multilingual classrooms prefer to teach and learn mathematics in English despite the learners' limited proficiency in it?
- Why is a majority of learners in multilingual classrooms not motivated to study mathematics?

Poor performance by multilingual learners cannot be solely attributed to the learners' limited proficiency in English (suggesting that fluency in English will solve all problems) in isolation from the pedagogic issues specific to mathematics as well as the wider social, cultural and political factors that infuse schooling.

Interpretations of the problem

- Its about mathematics itself
 - *Learning mathematics is similar to learning a language*
 - *Mathematics functions as both medium and message*
(Pimm, 1987)
- Its about language
 - *But solving the language fluency issues alone will not solve the problems*
- Its about the quality of mathematics teaching and learning in multilingual classrooms

It is about all these three:

mathematics, language and pedagogy!

Central to the problem is a need to address the uneven distribution of knowledge and success in mathematics.

To understand the problem

- We have spent time in multilingual primary and secondary mathematics classrooms in which both teachers and learners are multilingual and none has the language of learning and teaching as their home language
- Worked with 16 mathematics teachers in three different provinces in South Africa (Gauteng, North West and Limpopo)
- Observed & video recorded 60 primary mathematics lessons and 70 secondary mathematics lessons
 - What languages & language practices do they use?
 - How do they mediate mathematics learning?
 - What kind of mathematics discourses are prevalent in these classrooms?

What we found

- Dominance of English despite learners' limited fluency in it, accompanied by the prevalence of procedural discourse:
 - conversations, actions and behaviours focusing on the procedural steps to be taken to solve mathematics problems
- Limited occurrences of code-switching, accompanied by conceptual discourse:
 - conversations in which the reasons for calculating in particular ways and using particular procedures to solve a maths problem also become explicit topics of conversations

What we found

- Learners exposed to low cognitive demands mathematics tasks. For e.g.
 - a) *In the SPCA are 12 cages; in each cage are 12 dogs. How many dogs are there altogether? (in a Grade 4 class – data collected in 1998)*
 - b) *$2 + x = 8$, use algebra to solve for x . (in a Grade 11 class – data collected in 2003)*

... and more questions emerged

What shapes the nature of the mathematics taught and the language choices made in these classrooms?

What we found

- Teachers and learners prefer that English be used as the language of learning and teaching mathematics
- Because of the hegemony of English and the desire/need gain access to social goods e.g. higher education; jobs

Decisions about which language to use, how, and for what in multilingual mathematics classrooms are not just pedagogic but also political

What else did we find?

- Debates on language and mathematics teaching and learning (in the public domain & in research) tend to create dichotomies:
 - Teaching in English or teaching in the home languages;
 - Focusing on developing learners' fluency in English or on their mathematics proficiency;
 - Using cognitive or socio-political perspectives when researching language use in multilingual mathematics classrooms;
- Thus creating an impression that these are or must be in opposition.

More specifically...

How can we teach mathematics in these classrooms?

- Ensure that learners are sufficiently challenged mathematically & interested in learning mathematics**
- Offer the language support that learners need by drawing on multiple languages**
 - English, the language that learners want to gain fluency in and home languages that learners are fluent in.**
- Focus on developing mathematical proficiency while learners are still developing fluency in English**
- Draw on research that is informed by cognitive perspectives while taking into consideration the political nature and role of language and the background of the learners.**

Why focus on pedagogy as a possible solution?

- Research on productive pedagogies (Hayes, Mills, Christie & Lingard, 2006) and ways in which teachers can develop learners' mathematical proficiency (Kilpatrick, Swafford and Findell, 2001) through use of mathematical tasks with different cognitive demands (Stein, Smith, Henningsen and Silver, 2000)
 - does not have a language focus thus misses complexities of working in multilingual classrooms in which children are still learning English.
 - Need for pedagogy that foregrounds both mathematics and language
- As indicated earlier, debates on teaching and learning mathematics in multilingual classrooms tend to create dichotomies:
 - Learning in English or learning in the home languages; Cognitive or socio-political perspectives; Access to English or access to mathematics?
 - Thus creating an impression that these are or must be in opposition
 - Need for pedagogy that challenges these dichotomies.

Exploring a possible solution

A teaching strategy guided by two main principles:

1. the deliberate, strategic and proactive use of the learners' home languages.
 - unlike code-switching, which is spontaneous and reactive.
 - English and the learners' home languages operating together and not in opposition.
 - tasks given to learners in multiple languages.
 - learners are explicitly encouraged to interact in any language they feel comfortable with.
2. the use of interesting and challenging mathematical tasks,
 - Through this, learners would develop a different orientation towards mathematics and would be more motivated to study and use it.

What this solution is not about

- Developing the mathematics register or terminology in African languages
 - It is about using language as a transparent resource to make mathematics accessible to multilingual learners
- Developing a glossary of terms
 - It about comprehension rather than just terminology.
- Developing learners' fluency in English or their home languages
 - It is about developing the learners' mathematical proficiency
- Teaching solely in African languages
 - While this may be desirable it is not feasible at this stage given the demand for access to English

Some theoretical underpinnings

- An understanding of language as a resource (see for e.g. Adler; Barwell; Gorgorio & Planas; Khisty; Moschkovich; Secada; Setati, Staats)

A different conception of language as a resource

- For a resource to be useful it needs to be both visible and invisible (Lave and Wenger, 1991).
 - **Visibility** is in its presence and the form of extended access to mathematics it provides
 - **Invisibility** is in the form of unproblematic interpretation and integration of language(s) used
 - For e.g., the use of technology in mathematics teaching and learning.

How it works in the classroom

- Selection of tasks is very important
 - Examples of mathematics tasks we use
- Learners are organised into home language groups
- Learners in groups are given tasks in two languages: English and their home language.
- Learners are explicitly made aware of the two language versions of the task and encouraged to communicate in any language they feel comfortable with.

Exploring a possible solution: Case Studies

- Four Grade 11 multilingual mathematics classrooms
 - Terence's class – Soweto - 36 learners, 4 diff home languages (2 year)
 - Bheki's class – Thembisa - 29 learners, 4 diff home languages (2 years)
 - Nomsa's class - Ga-Rankuwa - 46 learners, one main language (one year)
 - Thikhathali's class - Soweto - 37 learners, 4 diff home language (one year)

COST OF ELECTRICITY

The Brahm Park electricity department charges R40 – 00 monthly service fees then an additional 20c per kilowatt-hour (kwh). A kilowatt-hour is the amount of electricity used in one hour at a constant power of one kilowatt.

- 1. The estimated monthly electricity consumption of a family home is 560 kwh. Predict what the monthly account would be for electricity.*
- 2. Three people live in a townhouse. Their monthly electricity account is approximately R180 – 00. How many kilowatt-hours per month do they usually use?*
- 3. In winter the average electricity consumption increases by 20%, what would the monthly account be for the family home in (1) above and for the townhouse?*
- 4. In your opinion, what may be the reason for the increase in the average electricity consumption in (3) above?*
- 5. Determine a formula to assist the electricity department to calculate the monthly electricity bill for any household. State clearly what your variables represent and the units used.*
- 6. a) Complete the following table showing the cost of electricity in Rand for differing amounts of electricity used:*

After careful consideration, the electricity department decided to alter their costing structure. They decided that there will no longer be a monthly service fee of R40 – 00 but now each kilowatt-hour will cost 25c.

7. What would be the new monthly electricity accounts for the family home and the townhouse?
8. a) Complete the following table showing the cost of electricity in Rand for differing amounts of electricity used using the new costing structure:

Consumption (kwh)	0	100	200	300	400	500	600	700	800	900
Cost (in Rand)										

- b) Draw a graph on the same set of axes in question 6.b. to illustrate the cost of electricity for different units of electricity using the new costing structure.
9. Do both the family home and the townhouse benefit from this new costing structure? Explain.
10. If people using the electricity had the option of choosing either of the two costing structures, which would you recommend? Clearly explain your answer using tables you have completed and graphs drawn in questions (6a) and (6b) and (8a) and (8b) above.

ISIZULU

Umnyango woGesi we Brahm Park ukhokhisa u-R40 – 00 ngenyanga wezindleko, bese ukhokhisa u-20c ngaphezulu nge kilowatt-hour (kwh). I-kilowatt-hour inani logesi olusetshenzisiwe ngehore uma amandla angashintshi ekilowatt elilodwa.

1. Ugesi osetshenziswa emndenini ubalelwa ku-560 kwh ngenyanga. Bala ukuthi lingaba yimalini intengo zogesi emndenini ngenyanga
2. Abantu abathathu bahlala kwi-townhouse. I-akhawunthi yahoo yogesi ngenyanga ingabalelwa ku R180-00. Amakilowatt amangaphi asetshenziswayo ngenyanga?
3. Ebusika ugesi osetshenziswayo ukhuphuku ngo 20%. Ingabe izoba yimalinmi i-akhawunthi ngenyanga yomndeni neye-townhouse ebusika?
4. Ngombono wakho iyini imbangela yalokukhuphuka kogesi ebusika?
5. Nikezela ngefomyula enganceda umnyango woGesi ukubala intengo zogesi ngenyanga noma iyiphi indlu. Usho hucace wonke ama-variable asetshenzisiwe ukuthi ameleni nama unithi asetshenzisiwe.
6. a). Qedela uhlu (ithebuli) elilandelayo elibonisa ngamaRandi intengo zogesi zenani ezihlukahlukene ezisetshenzisiwe:

Mandla's cinema hall can accommodate at most 150 people for one show.

- a) Rewrite the sentence above without using the words "at most".
- b) If there were 39 people who bought tickets for the first show, will the show go on?
- c) Peter argued that if there are 39 people with tickets then Mandla should not allow the show to go on because he will make a loss. Do you agree? Why do you agree?
- d) What expenses do you think Mandla incurs for one show?
- e) Use restrictions to modify the statement above in order to make sure that Mandla does not make a loss.
- f) If Mary was number 151 in the queue to buy a ticket for the show, will they accommodate her in the show? Explain your answer.

Derrick owns a hair salon. He specializes in two types of hairstyles: the dreadlocks and singles. Lets assume that x represents the number of dreadlocks hairstyles and y represents the number of singles hairstyles. It takes at least one hour to do a dreadlocks hairstyle and at least 5 hours to do a singles hairstyle and Derrick can only work up 8 hours per day. It costs at most R40 to do dreadlocks and a maximum of R60 to do singles.

Derrick has a problem: He makes a profit of R20 on dreadlocks and a profit of R35 on singles. Because of his other commitments Derrick still wishes to work for a maximum of 8 hours a day only. How many dreadlocks hairstyles and singles hairstyles will give Derrick maximum profit?

What our analysis shows?

- Learners' engagement with higher cognitive level demand mathematics.
- Dominance of conceptual talk during lessons

T: Okay, if you use electricity ukho bhadala forty rand [*Okay, if you use electricity will you pay forty rand*]?

Ls: Yes meneer [*Yes sir*].

T: If unga shumisanga electricity ukho bhadala forty rand [*If you did not consume electricity, will you pay forty rand*]?

Sipho: No, no no ...

Given: Haena, whether ushumisile ore haushumisanga, ukhobhadala forty rhanda [*No, whether you have consumed electricity or not, you pay the forty rand*].

T: Whether ushumisile ore haushumisanga? [*Whether consumed or not?*].

Sipho: Eya, yes, it is a must.

T: It is a must?

Given: Hei, nayo...ah...(Giggles)...So forty rhanda hi monthly cost ne, then ba yieda nga twenty cents kha kilowatt for one hour. Then after that, angado shumisa...baibidza mini? Heyi ... ndoshumisa one kilowatt nga twenty cents kha one hour ***[Hei, this question ... ah ...(giggles) ... So forty rand is the monthly cost, then they add twenty cents per kilowatt-hour. ..., they use..., what do they call it? Heyi ... they use one kilowatt-hour for twenty cents].***

Sipho: Eya ***[Yes].***

Given: Boyieda, maybe boshumisa twenty cents nga one hour ***[They add it, maybe they use twenty cents per hour].***

Sipho: Eya, yantha ***[Yes, one hour].***

Given: Iba ... ***[It becomes...].***

Given and Sipho: Forty rand twenty cents.

Sipho: Yes, vhoibadela monthly, ngangwedzi ya hona. Yo fhelela, yes. Sesiyaqubheka. ***[Yes, they pay it monthly, each month. It is complete, yes. We continue].***

What our analysis shows?

- This approach creates an opportunity for learners to engage with higher cognitive level demand mathematics tasks.
- Dominance of conceptual talk during lessons
 - Lesson transcript
- Language functioning as a transparent resource (visible and invisible)
 - Lesson transcripts
 - Learner interviews
- Learner participation and interest in mathematics.
 - Lesson transcripts
 - Learner interviews

Learners' reflections

Interviewer: I understand this week you had visitors in your class, what was happening?

Sindiswa: Er..., we were learning a lesson in which we can calculate electricity er amount ... er ... the way in which the electricity department can calculate the amount of electricity unit per household.

Nhlanhla: We were learning about how to calculate ...er...er... kilowatts of the electricity, how do we ... like ... how can we calculate them and when ... at ..., Besifunda mem ukuthi ugesi uleka kakhulu nini.

[We were learning about when there is high electricity consumption.]

Colbert: Er ...we were just solving for electricity, kilowatt per hour, for comparing if they are using card or the meter, which is both, I think are the same.

Sipho: Er, the visitors they were doing research.

Interviewer: What ... what was so special about the lessons?

Sindiswa: It does not include those maths ... maths. It is not different, but those words used in Maths didn't occur, didn't occur but we weren't using them. ... Er ... 'simplifying', 'finding the formulas', 'similarities', ...

Nhlanhla: Hayi, no mem, ku-different... Okokuqala mem, ilokhuza, la sidila ngama-calculations awemali, manje ku-maths asisebenzi ngemali.

[No mam, it is different. Firstly mam, we were working with money and usually in maths we do not work with money.]

Colbert: Iya, basenzele in order to ... ukuthi ibe simple and easy to us, because most of people, uyabona, aba-understendi like i ... like i-card ne meter. Abanye bathi i-meter is ... i-price yakhona i-much uyabona, i-card iless i-price yakhona, that's why uyabona. So, abantu abana-knowledge, uyabona, bakhuluma just for the sake of it. So, I think for us, because we have learnt something, both are the same.

[yes, you see they made it easy for us, because most people do not understand, like card or using a meter. Some say when using the card you pay less than when using the meter, you see. So people do not have knowledge out there, they just talk for the sake of it. So think, for us we have learnt something, both are the same.]

Interviewer: So what is it that you like about the new approach that Mr Molefe was using?

Sindiswa: Ke gore, the way ne diquestion di ne di botswa ka teng, it was easy for the whole class for all of us, for all the students to understand and answer all the questions.

[The way the questions were asked, it was easy for the whole class, for all of us, for all students to understand and answer all the questions.]

Nhlanhla: I think iyasebenza, ngoba ama-learners amaningi, maybe like, uma ungasebenzise ama-home language wabo, abaphathisipheiti kakhulu. Mabanikezwa ama-home language abo, I think bazokhona ukuphathisipheita.

[I think it works because many learners, maybe like, when their home language are not used they do not participate. When they are given their home languages, then they are able to participate.]

Colbert: Because most of us we are ... be baphathisipheita. The whole class, I think be-iphathisipheitha. But before beyiyenza ukuthi like, beyi ... bebabona nje i-class, kukuthishwa maybe four learners uyabona, others ... (Inaudible).

[Because most of us we are...we were participating. The whole class I think was participating. But before then, it was as if the teacher is talking to only four learners, others ...]

Sipho: Because kaofela digroup they were participating, wa utlwisisa mam. Le bane ba sa phathisipheiti ko klaseng, ne setse ba phathisipheita. Nna ke maketse gore 'he banna, mothaka o kajeko ke ena oe arabang so Maths' (Clicking fingers).

[Because all the groups were participating, you understand mam. Even those who never participate were participating. I was surprised that 'hey man, even this guy is answering questions today in maths?']

What we can say about the pedagogy at this stage?

- Potential to increase learner participation and interest in mathematics
- Engagement with higher cognitive level demand mathematics tasks
- Language as a transparent resource

What we know?

- There is no single, universal teaching strategy that suits all learners, situations and contexts
- Different kinds of multilingual classrooms may need different strategies.

In short

What difference is this solution making?

- The nature of mathematics tasks
 - **From**: *In the SPCA are 12 cages; in each cage are 12 dogs. How many dogs are there altogether?* **TO**
 - **From**: $2 + x = 8$, use algebra to solve for x **TO**
- Use of languages
 - **From** choosing one language for learning **TO** drawing on multiple languages during learning
- Mathematics discourses
 - **From** abbreviated one word responses **TO** explanations of how particular problems are solved and why

Research

- There is a need for more research in this area of study
- This area of study is politically charged
- Transdisciplinary demands (e.g. mathematics, linguistics, education)
- The need for multilingual and transdisciplinary research teams

Key theoretical shifts in the field

- From bilingualism to multilingualism - a global phenomenon, which until the nineties was not taken into consideration by research in mathematics education (Adler, 1995; 1997)
- From constructing language diversity as a problem to constructing it as a resource
- From a conception of language only as a tool for thinking and communication to a recognition of the political role of language and how that shapes mathematics teaching and learning in linguistically diverse classroom as well as research in this area of study (Setati, 2005).
 - language choices in linguistically diverse classrooms are also shaped by the economic and socio-political context in which learning takes place.

Theoretical contribution

Where the journey is at?

- Exploring the problem in different multilingual mathematics classrooms in South Africa
 - Those with majority immigrant multilingual learners and teachers whose main languages are not official languages in SA
 - Those in which immigrant mathematics learners and teachers are a minority
 - Those which are located closer to the boarder

What we still do not know?

- Is the transparent use of language in multilingual mathematics classrooms *the* solution?
 - Does it work in all kinds of multilingual classrooms?
- What do all educators need to know, and what skills do they need in order to be able to teach mathematics effectively in multilingual classrooms?
- What changes are required in mathematics teacher education to ensure that future teachers are adequately prepared to maximise the personal, linguistic and mathematical potential of learners in multilingual classrooms?

**NGIYABONGA!
KE A LEBOGA!
THANK YOU!
DANKIE!
ENKOMO!
NDIYABULELA!
NDO LIVHUWA!
ASANTE SANA!**