

CoPF Report August 2014
FRF Mathematics Education Chair
Rhodes University, Grahamstown
Marc Schäfer

www.ru.ac.za/mathsedchair



FRF MATHEMATICS
EDUCATION CHAIR



RHODES UNIVERSITY
Where leaders learn

The Team



Marc, Helen, Duncan and Nyameka

Scratching the surface of complexity we've only just begun





- Current reporting period

- General findings – some reflections

- Proposal for next cycle

2013 - 2014



MTEP – Mathematics Teacher
Enrichment Programme



Research agenda

...through an action research-type process...

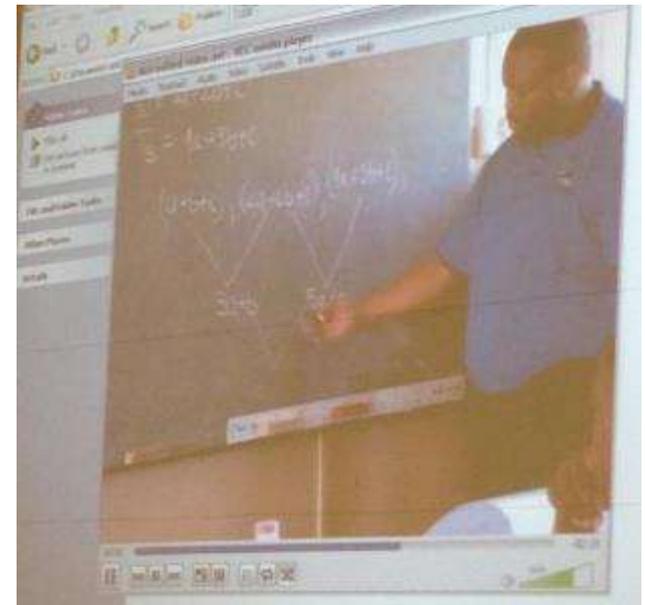
MTEP

5 RESEARCH QUESTIONS

2014 - MTEP



- Regular seminars/sessions on a Tuesday 15h00 – 17h00
- Introduction of one full-day programme per term
- Driven by mathematical ideas, content, moments - NOT the national curriculum
- Assegai Trails Mathematics retreat
- In-school-support programme
- Grade 10 quizzes
- Lesson video analysis
- Intertwined with our research agenda
- Continued emphasis on notions of conceptual teaching and learning
- RUME



The research questions that have formed the basis of our research activities are:

1. What appropriate teaching strategies could assist in building confidence and proficiency in Mathematics teachers?
2. How can a positive professional identity be grown?
3. What is the nature of the mathematics backlog of our pupils?
4. How can effective and innovative learning and teaching resources be developed?
5. What is the impact of the work of the Chair?

Our theoretical framings

- Enactivism – the teaching and learning process is a complex co-evolving process of systems interacting and affecting each other within body, mind and world spaces. Teaching and learning is active and dynamic, and a space where the two co-emerge. The one cannot exist without the other. This interconnectivity provides us with useful vantage points to theoretically and empirically, research our activities.
(Proulx, Simmt, Begg, Davis)
- Situated perspective – teaching and learning seen as participation in a community of practice. Teaching and learning is an ongoing, social, interactional process.
(Wenger, 1998)
- Theory of change – journey from an current/actual identity to a designated identity
(Sfard)
- Conceptual pedagogy – proficiency discourse (Kilpatrick et al.)

How the projects and the research of the students of the FRF Mathematics Education Chair relate to the 5 Research Questions



*A Community of Scholars * Synergy and Coherence
Teaching for Conceptual Understanding*

Some highlights of 2013 - 2014



Dr Duncan Samson
2014 SAARMSTE emergent
researcher of the year award



Assegaai Mathematics retreat



End-of-year award ceremony

Presented 9 papers at SAARMSTE 2014

Ranked 7th in the Rhodes University Research outputs table

Associated projects integral to MTEP and our research

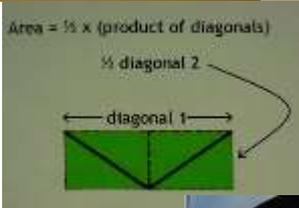
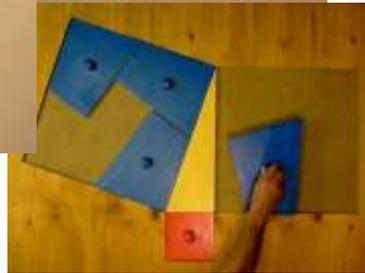
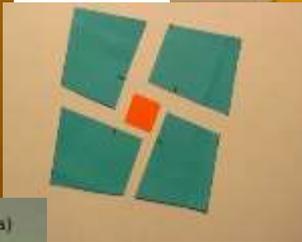
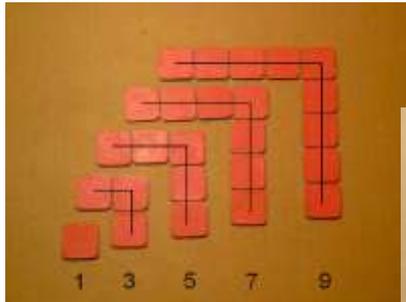
VITALmaths project

Catch-up project

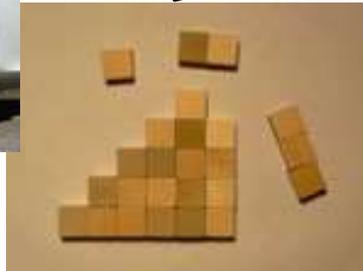
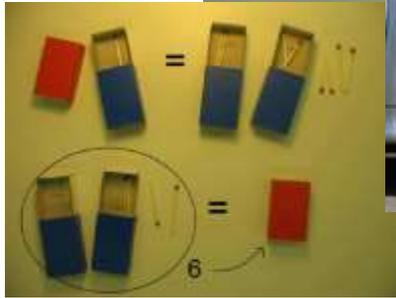
GADRA and RUME – our community outreach

VITALmaths project

www.ru.ac.za/vitalmaths
www.facebook.com/VITALmaths



www.youtube.com/user/vitalmaths



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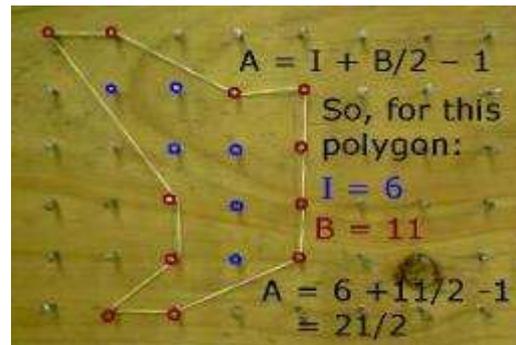
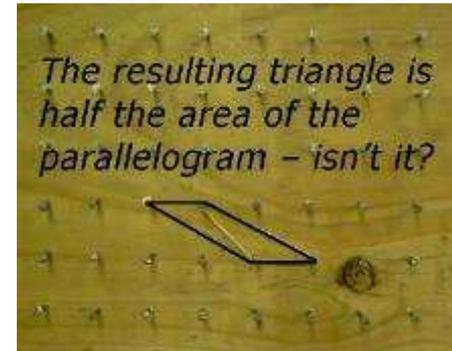
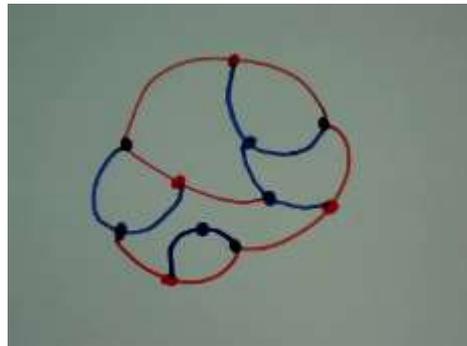
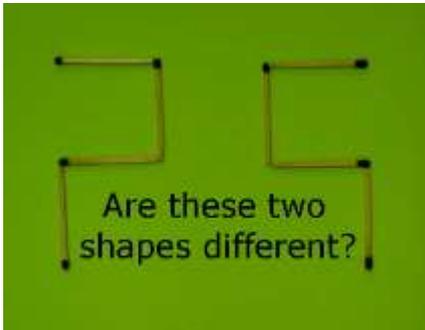
Fachhochschule Nordwestschweiz
Pädagogische Hochschule



The three underlying themes that frame the VITALmathsLIC project relate to (i) communication, (ii) language and discourse, and (iii) manipulatives:

- i. How can our video clips and materials be used to enhance learning in a collaborative and social milieu?
- ii. How can the video clips and materials enhance mathematical learning through engaging an appropriate mathematical discourse and language?
- iii. How can the video clips and materials encourage the use of physical manipulatives to enhance learning?

As part of the VITALmathsLIC project, nine new video clips have already been added to the steadily growing databank of video clips.



Received joint funding from the NRF and the SNF

Catch – up project



The focus of the Catch-Up Project for the majority of the reporting period has been geometry. The rationale for this focus was based on benchmark testing which indicated that Geometry and Space & Shape were two of the weakest areas for our Grade 10 learners.

Grade 10 benchmark testing

| | | Alg & Equ | Number sense | Space & Shape | Stats & Prob | Func & Graphs | Geom |
|------|-----|-----------|--------------|---------------|--------------|---------------|------|
| 2011 | G10 | 33% | 32% | 16% | 44% | 18% | 18% |
| Pre | | | | | | | |
| 2012 | G10 | 23% | 25% | 6% | 31% | 1% | 13% |
| Pre | | | | | | | |
| 2013 | G10 | 22% | 25% | 5% | 30% | 1% | 12% |
| Pre | | | | | | | |
| 2014 | G10 | 17% | 19% | 4% | 27% | 3% | 12% |
| Pre | | | | | | | |

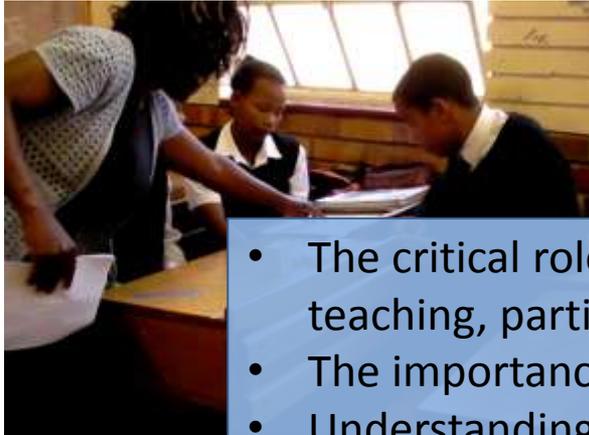


FOCUS OF NEXT 5-YEAR CYCLE

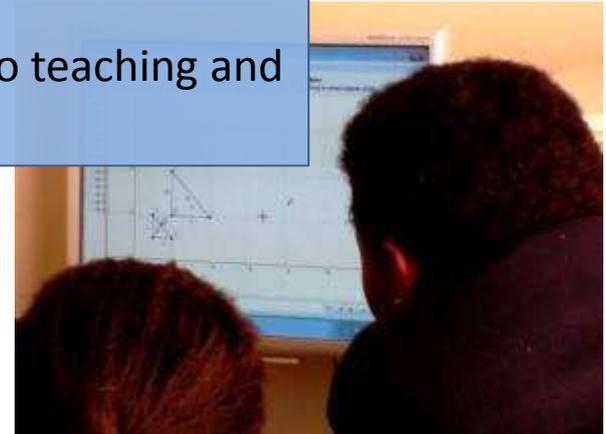
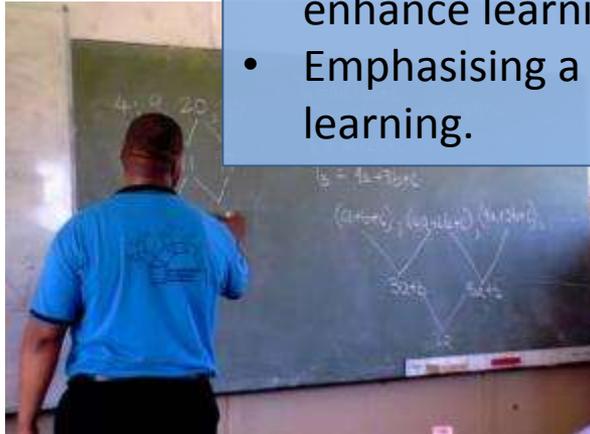
GADRA and RUME – our community outreach



OUR MAIN FINDINGS FROM OUR RESEARCH



- The critical role of **manipulatives** in learning and teaching, particularly in secondary school contexts.
- The importance of growing a **professional identity**
- Understanding and catching up the overwhelming **backlogs** of our learners
- Harnessing the use of **mobile technology** to enhance learning and teaching
- Emphasising a **conceptual** approach to teaching and learning.



Our research outputs over the past 5 years have been solid.
In a nutshell these are:

Masters students

| | |
|------------------|---|
| Completed | 5 |
| About to submit | 1 |
| Current | 3 |
| Newly registered | 3 |

Doctoral scholars

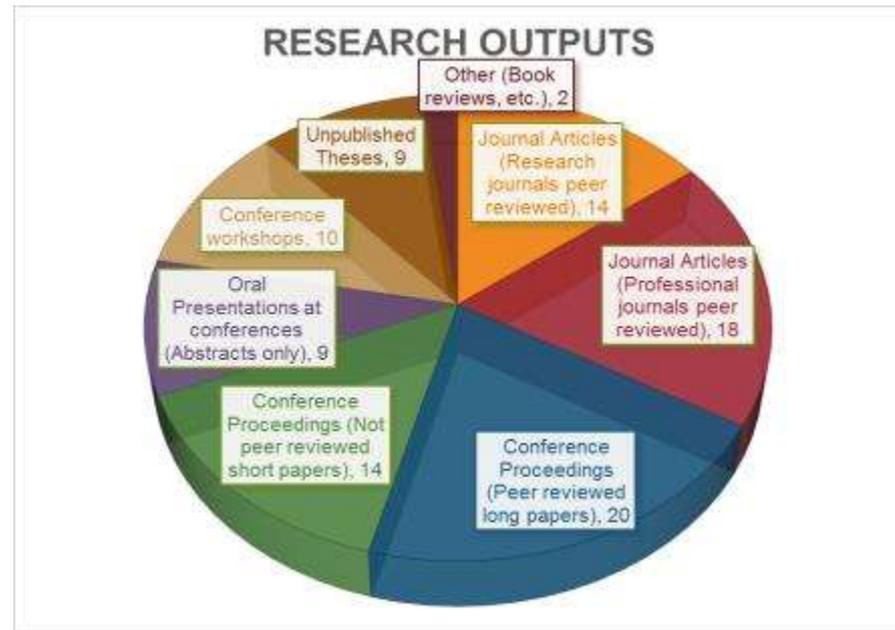
| | |
|----------------------|---|
| Completed | 3 |
| Submission this year | 3 |
| Newly registered | 2 |

Post docs

| | |
|-----------|---|
| Completed | 2 |
|-----------|---|

INFLUENCE

We have published just under **100 articles** in refereed journals (international and national), professional journals, books and conference proceedings of which in **excess of 75 relate directly** to the project.



Teaching strategies that enhance teaching proficiency – RQ 1

- Kilpatrick's five strands of teaching proficiency should be used as a framework to reflect on and assess teacher proficiency and effectiveness
- Enactivism can form a useful and meaningful theoretical basis to reflect on teacher practice
- A productive disposition is a key ingredient for effective teaching
- The teachers effectiveness is characterised by a high level of content knowledge, rich personal experience, sustained commitment, effective and careful preparation for lessons, high expectations of themselves and learners, collegiality, passion for mathematics and an excellent work ethic;
- With regard to teachers' effective geometry teaching practices, these were characterised by making use of real-world connections, manipulatives and representations, encouraging a collaborative approach and working together to show that geometry constituted a bridge between the concrete and abstract.
- As much as code-switching is a legitimate and resourceful teaching strategy there are substantial inconsistencies in the way teachers code switch.
- Teachers that codeswitch often operate consistently in the public domain or everyday mode of talking, but not so within the esoteric (mathematical) mode. Very little transparent code switching which supports students' understanding and thinking in mathematics, is evident in teacher language. Teachers make extensive use of borrowed terms.
- Teachers receive very little support in developing best practices for code switching.
- For code switching to remain a legitimate teaching strategy, there is a need for the development of mathematical registers in indigenous language so that teachers can code-switch consistently and precisely into those languages.

The importance of growing a positive professional identity – RQ 2

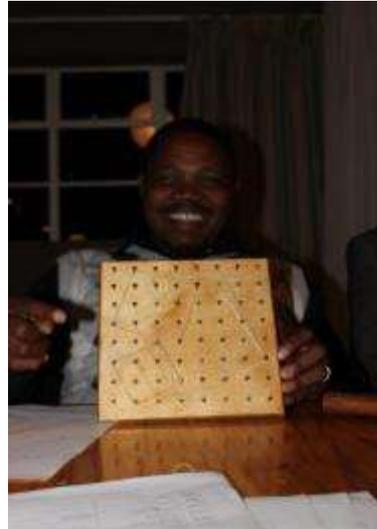
- Understanding of teachers' past narratives is crucial in the cultivation of a positive professional identity.
- A positive professional identity is central to the practice of any teacher.
- In the context of South Africa's complex past, it is very important to recognise and integrate past narratives of teachers in pre- and in-service teacher education courses.
 - In-service development programmes such as MTEP are crucial in the cultivation of a positive professional identity
 - Emphasising and adopting a conceptual approach to teaching by using manipulatives and other hands-on resources builds confidence in ones' teaching. This in turn cultivates a positive professional identity.
 - Beginner teachers are not adequately mentored and supported in developing their teaching careers and professional identities .
 - The shaping of a professional identity for beginner teachers requires an elaborate induction process that includes professional support, belonging to a functional community of practice, and exposure to proficient teaching.

Addressing the huge backlogs in our learners – RQ 3

- The majority of Grade 10 learners have very poor understanding of key basic primary school concepts such as congruency, verticality and horizontality.
- Most learners are unable to differentiate between terms such as congruent and similar.
- Many Grade 10 learners are unable to mentally rotate shapes and objects to view them from different perspectives.
- The majority of learners achieved greater success with real world context tasks than with text book type tasks.
- Remediation strategies are crucial to catch up lost ground if Grade 10 learners are to be proficient and successful in Mathematics in Grade 11 and 12
- Nearly 70% of Grade 10 learners in Grahamstown experience boredom in their mathematics classroom.
- The distribution of the above is not even amongst schools. Generally learners from township schools are less bored than learners from ex-model C and private schools.
- The reasons for being bored are manifold. The range from ineffective teaching, being demotivated and disinterested, to not being able to understand the abstract nature of Mathematics and doing poorly in its assessment.

Teaching resources that can enhance teaching and learning – RQ 4

- Using physical manipulatives should play a major role in learners' learning.
- The use of physical manipulatives in the classroom were found to:
 - motivate learners to concentrate on the task at hand,
 - clarify and simplify concepts that would have been difficult to understand without the use of physical manipulatives,
 - open up group discussion where all learners are actively involved in their own learning, and
 - provide learners with something new to think and reflect on as the lesson unfolds
- Using manipulatives in teaching enables:
 - conceptual teaching and learning
 - visualisation of mathematical concepts.
- Physical manipulatives help learners to construct a clear understanding of mathematical concepts that are often perceived as obscure.



ACTIVITY 25 – Doublestacking

Begin with a 3 by 3 grid like the one at right. Place 9 cubes on the grid according to the following order:

- 3 cubes must be placed in any of the 4 cells on the grid.
- 2 cubes must both be placed diagonally on top of the single cube to form a second layer.

How many ways are there of doing this? In other words, how many different doublestacking structures can be built according to these rules?

To solve this problem, first we identify the 4 possible ways:

If we take the 4 structures of these four arrangements, then there are four possible possibilities for the second layer.

So, how many different doublestacking structures can be built in total?

- Let's now start with a 3 by 3 grid like shown in the grid and place 3 cubes in the bottom layer and 4 cubes in the second layer. How many ways are there to do this?
- How many ways are there when we place 3 cubes in the bottom layer and only 3 cubes in the second layer? How many ways are there to do this?
- Investigate other possibilities. You may wish to construct the doublestacking 3x3 grids.

BRUNNEN LEARNING
www.brunnen.com

The use of VITALmaths clips through the medium of the cellphone:

- Increases teacher enthusiasm
- Increases learner enthusiasm and motivation
- Learner participation
- Promotes hands-on-activities
- Facilitates exploration and investigation
- Increases learner engagement and participation
- Facilitates visualisation
- Assists in explaining difficult concepts
- Enables learners to access Mathematics outside of the classroom
- Encourages hands-on activities
- Provides for teacher enrichment
- Facilitated a different teaching approach

Generally using visual technologies with cell phones enables:

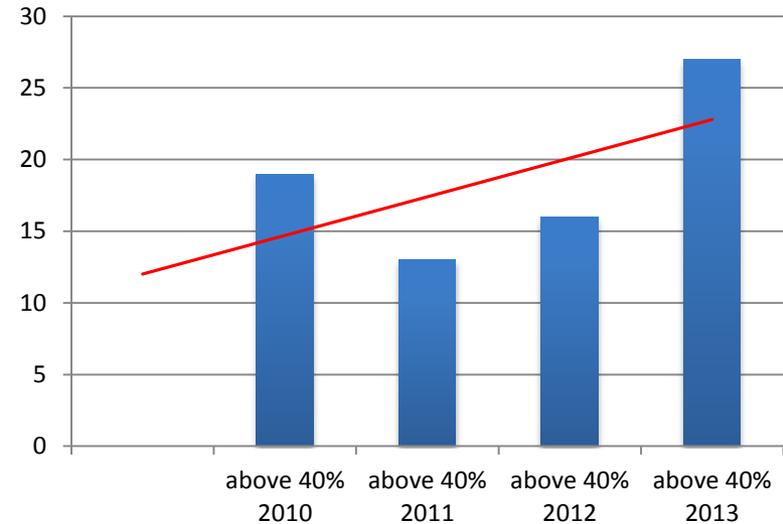
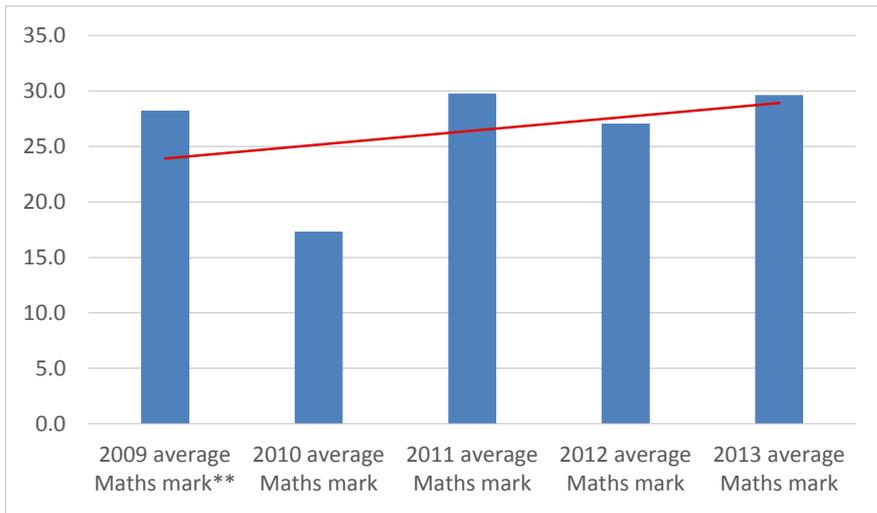
- Learner participation, engagement and collaboration
- Inspires autonomy and motivation in the users
- Encourages users to explore the hands-on activities



The implementation of the Singapore Mathematic Curriculum (SMC) has the potential to enhance successful teaching and learning in Mathematics in South Africa.

- An adapted SMC teaching strategy facilitated the discovery of mathematics using a variety of manipulatives as recommended by the SMC;
 - the use of the SMC model method to solve problems helps students visualise mathematical problems;
 - the teachers' understanding of teaching for mathematical proficiency is enhanced;
 - the SMC teaching approach provides constant opportunities for creativity and logical thinking, and
 - Using an SMC approach can change the attitude of both students and teachers resulting in greater confidence when working with non-routine, open-ended problem-solving activities.
-
- The inclusion of indigenous cultural artefacts such a dance enhances the teaching and learning experience.
 - An abundance of mathematical concepts are embedded in traditional Xhosa dance that should be harnessed in the mathematics classroom

Impact of our work – RQ 5



Improved results

A community of practice

Conceptual teaching

Teacher participation

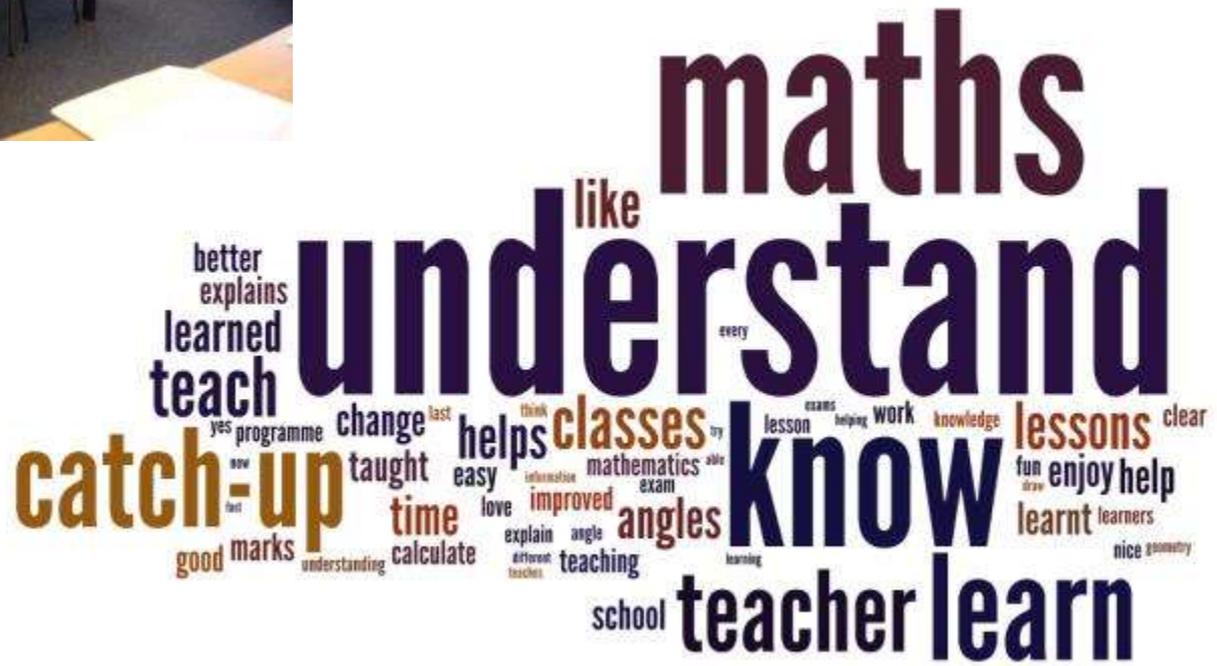
Growing a positive identity

Content awareness

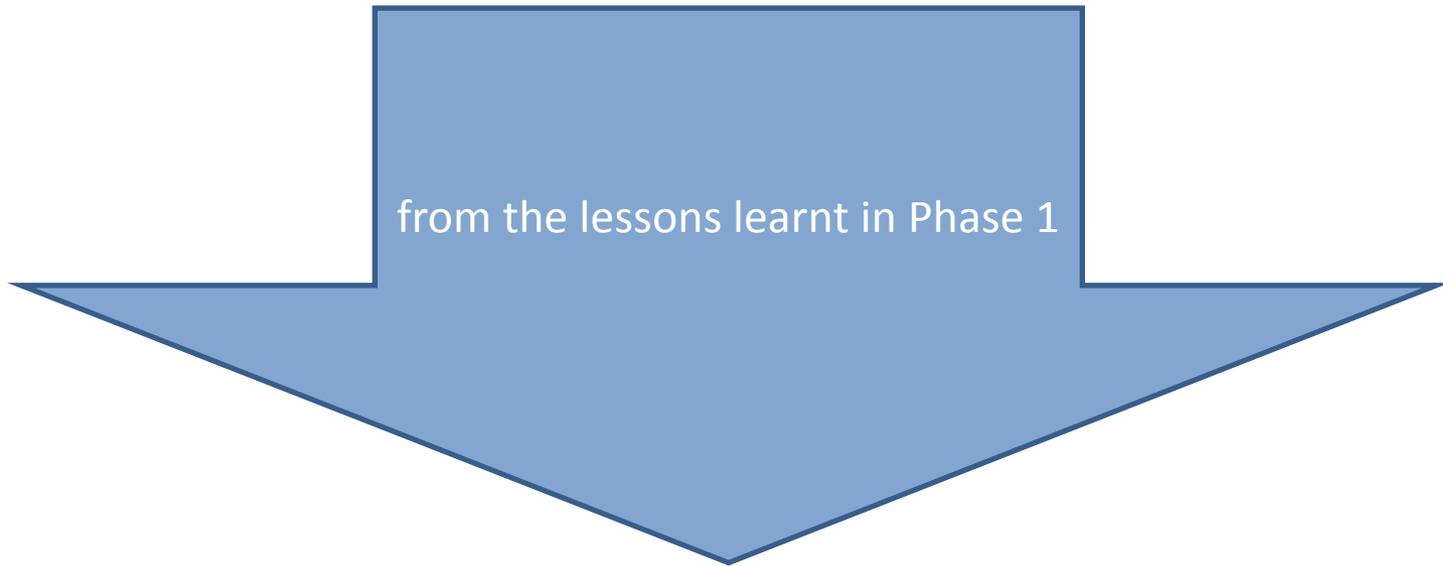
Publishing and sharing of good practice

Potential of visual technologies

Capacity building – students, teachers and staff



LOOKING AHEAD



Continuity

- Similar research/development design - the one informing the other
- Same education district
- Research students are integral to the development programme

New focus

- Re-orientation to Grade 8 and Grade 9
- Space & shape/Geometry focus
- Teacher **and** pupil intervention
- Combination of types of schools

Development objectives

- To sustain and strengthen the momentum of MTEP and create a new community of practice consisting of Grade 8 – 10 teachers from selected state high schools in the Grahamstown Education District. This community of practice will consist of new teachers and some of the existing MTEP teachers.
- A community of 20 Grade 8 – 10 teachers from 10 selected state schools. The selected schools will all be functional schools and consist of a mixture of ex model C schools and township schools.

- To develop, mentor and grow
 - a) teacher mathematical knowledge in Geometry,
 - b) pedagogical knowledge in Geometry with the participating teachers,
 - c) a self-sustaining peer tutoring programme in each of the participating schools. This will be based on Matthew Kellen's work on peer learning. The programme will take the form of extra-mural clubs in each school,
 - d) a reflexive teacher practice that includes classroom based research with rigorous conversations about practice.

a) and b) will be achieved through a programme consisting of:

 - regular contact days
 - retreat weekends
 - in-school support

Regular lesson video analysis will be done to assess and evaluate progress

c) will be achieved through establishing extra-mural clubs in clusters of schools

- To engage deeply with pedagogical and didactical issue around:
 - e) Conceptual development in Geometry (space and shape)
 - f) Visualisation
 - g) Communication
 - h) Use of technology such as VITALmaths and GeoGebra

- To collaborate with other development initiatives to capitalise on expertise and capacity in developing exciting teaching and learning spaces A cohort of post-graduate students whose research projects will be aligned to the issues d) – g).

Research objectives

The following research themes, within the context of the Grade 8 – 10 geometry classroom, are envisaged:

- a. Teaching for conceptual understanding in Geometry
- b. Teaching and learning with visual technologies (VITALmaths) to support geometry teaching and learning
- c. Spatial skill/ability assessment leading to appropriate remediation
- d. Language for Geometry teaching/learning and language in Geometry teaching/learning
- e. Making connections in Geometry with other mathematical and real-world domains.

A community of post-graduate scholars (MEds and PhDs – preferably full-time) to research within and across the listed themes will be established.

Specific research questions will arise, and then refined in the first year of the project once the intended community of practice has been established and the symbiotic relationship between research and development has been allowed to grow.

The overarching theoretical framework will be informed by the work of Newcombe and Shipley (2012) and Del Grande (1990). Jane Cowley, one of our present MEd students, is currently using an amalgamated framework that identifies 6 key spatial skills that are fundamental to developing specialised spatial capacity for mathematical problem solving. These are illustrated below:

| Skill according to Del Grande (1990) | Definition | Relevance to Geometry | Schema of Newcombe and Shipley (2012) |
|--|---|---|---------------------------------------|
| Figure-ground perception | The ability to identify a specific component against a background of intersecting and hidden forms. | Isolating the relevant shapes or objects from a complex diagram in order to solve a Geometry problem. | Intrinsic-static |
| Visual discrimination | The ability to identify and classify 2D shapes and 3D objects according to their similarities and differences. | Honing classification skills and working with similarity and congruency. | Intrinsic-static |
| Spatial visualisation | The ability to visualise imaginary movements in 3D space, or to manipulate objects in the imagination. (e.g. folding paper and perforating it, cutting shapes, etc) | Making mental adjustments to shapes and objects that have undergone change, e.g. forming a 3-D object from a net. Visualising inverse functions on a set of axes. | Intrinsic-dynamic |
| Spatial orientation (also called position-in-space perception) | The ability to imagine how a shape would look from a different angle or perspective. | Adjusting the orientation of shapes or objects to assess their similarity or congruency. Understanding the translation of shapes. | Extrinsic-dynamic |
| Spatial perception (also called perceptual constancy) | Understanding abstract spatial principles such as horizontal invariance or verticality. | Strengthening concepts such as perpendicularity and parallelism. Finding the perpendicular height of a triangle. | Extrinsic-static |
| Perspective | Visualising a scene in its entirety when looking from a different position. | Correctly identifying shapes and objects from unfamiliar perspectives, such as above or below. | Extrinsic-dynamic |

It is envisaged that the proposed programme for the second five year period will thus focus on developing and researching:

- teaching proficiency to teach the above skills and
- growth in personal mathematical/geometrical proficiency and ability.

The articulation between the development and research agendas will grow by once again letting the symbiotic and emerging process of the two agendas unfold in the first two years of the project. This worked very well in the first five years of the project and we would like to capitalise on the skills we have developed in this regard.

YEAR 1
2015

Consolidation of previous 5 years:

- Finishing off supervision of current student research project and their work – 6 MEd and 2 PhDs
- Writing a final narrative in the form of a book of all the lessons learnt in the initial 5-year phase. The Chair will be the first author and co-ordinator, and all the students and co-workers will be invited to be co-authors.
- Writing up of papers and conference papers

Planning:

- Planning of development and research agenda
- Recruiting of staff and post-grad students
- Selection/recruiting of schools and participants
- Setting up of workable and well-planned evaluation process – including articulating the evaluation indicators
- Benchmark testing
- Collecting baseline data
- Continuation of VITALmaths project as planned
- Setting up of GeoGebra website for 2 PhD studies
- Identifying and recruiting partners
- Framework for measuring teacher/pupil shift

YEAR 2
2016

- Implementation of the intervention/development programme
- Finalising the research agenda and research questions
- Commencing and continuation of research programme
- Setting up of extra-mural club in one pilot cluster of schools
- Setting up of peer tutor groups in these clubs
- Commencement of new cohort/cycle of 2-year MEd coursework

| YEAR 3 2017 | YEAR 4 2018 | YEAR 5 2019 |
|--|---|---|
| <ul style="list-style-type: none">• Implementation of development and research agenda• Finishing MEd cycle• Establishing remaining clubs• Midterm evaluation at the END of the year | <ul style="list-style-type: none">• Implementation of development and research agenda• Commencement of a new MEd coursework cohort | <ul style="list-style-type: none">• Implementation of development and research agenda• Finishing MEd cycle• Consolidation and evaluation of programme |

How are we going to measure shift?

A detailed and workable framework of indicators for shift in teacher practice and knowledge will be devised in the first year of the project once staff have been appointed and the curriculum for the development programme has been negotiated and finalised. Once again it is envisaged that both qualitative and quantitative data will be used to answer the indicators.

Examples of quantitative data that can be used to measure shift:

- rigorous and regular benchmark testing. We have gained valuable experience and expertise in setting up and implementing benchmark tests,
- regular evaluations in form of questionnaires and interviews,
- ANA results – these are particularly relevant in the Grades we wish to work in,
- School/pupil performance – our GeoGebra website

Examples of qualitative data that can be used to measure shift:

- lesson video analysis,
- post-graduate students' case study research – many of our students will engage in classroom-based research interrogating teacher practice,
- disposition/identity questionnaires and interviews.

Specific tangible outputs from the development work:

- establishment of self-sustaining peer learning clubs in cluster of schools,
- improved pupil performance in geometry in the participating schools,
- improved conceptual understanding of fundamental primary school geometry concepts,
- improved teaching that uses manipulatives for facilitating visualisation of geometrical concepts,
- improved teaching that reflects cross-curricular connections,
- a dynamic and active community of practice of Grade 8 – 10 mathematics teachers.

Our international guests and collaborators



Professor Helmut Linneweber-Lammerskitten
VITALmaths project



Professors Jerome Proulx and Elaine Simmt
Enactivism



Professor Reinhard Holz
GeoGebra project



Professor John Mason
Teacher development



Dr Boris Girnat
VITALmaths project

CONCERNS

- Number and nature of evaluations
- Non-articulation of evaluations
- Continuation into Phase 2
- Scope of bursaries and student grants
- Communication of our findings

THANK YOU FOR YOUR ATTENTION