Reflections on the South African Maths Education Chairs Initiative (MECI)

LESSONS LEARNT FROM CSI-FUNDED ECD PROGRAMMES IN SOUTH AFRICA

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Introduction
Mathematics education is a topical subject in South Africa that continues to attract enormous attention from government, civil society, academics and researchers, and private sector entities. Maths is regarded as a gateway subject that lays the foundation for tertiary education and careers in fields such as engineering, medicine, bio-technology, pharmacy, actuarial science, finance and business administration. A solid grounding in mathematics is also critical for success across the spectrum of careers and sectors. South Africa’s economy urgently needs tertiary level mathematics and science skills and expertise for scientific, technological and social innovations, poverty reduction and elimination of inequality in the society. However, the poor quality of mathematics teaching at schools limits the range and level of understanding of students entering both undergraduate and postgraduate programmes of study.

Although the proportion of learners participating in mathematics is increasing, there is still evidence that the country is failing to produce adequate numbers of graduates with passes in maths and science subjects.\(^1\) Assessments at the national level indicate that performance in maths and science is generally poor.\(^2\) For instance, in a systemic evaluation conducted by the Department of Education (DoE) in 2003, grade 3 learners achieved an average score of 30% in numeracy and 54% in literacy. In 2004, the DoE conducted similar evaluations for grade 6 learners and the results showed an average of 27% in maths and 41% in natural science.\(^3\) Almost a decade later the results are still dismal. The 2013 ANAs for grade 4 recorded an average mark of 37% on the maths component while for Grade 9 the average score was 14%.

Further evidence shows a decrease in the number of grade 12 learners passing maths from 55.7% in 2005 to 46.3% in 2011. However, in 2012 the number of grade 12 learners who passed maths increased to 54%.\(^4\) This figure further increased to 59% in 2013.\(^5\) Learner performance in science increased from 36.8% in 2009 to 53.4% in 2011.\(^6\) The pass rate for science increased to 61.3% in 2012 and then to 67% in 2013.\(^7\)

Various initiatives at different levels within the education system have been implemented with a view to address this maths crisis. These initiatives have focused on both educators and learners. The FirstRand Foundation South African Maths Education Chairs Initiative (MECI) is an example of one such intervention.

This paper provides a brief overview of the MECI and captures the emerging lessons.

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\(^7\) DBE, 2013. Statement during the announcement of the 2012 National Senior Certificate Grade 12 Examination Results by Mrs Angie Motshekga, Minister of Basic Education; SABC Auditorium.
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1. South African Research Chairs Initiative
As a national response to human resources challenges in the country, the South African Research Chairs Initiative (SARChI) was established in 2006 by the Department of Science and Technology (DST) and the National Research Foundation (NRF). This initiative is designed to attract and retain excellence in research and innovation at South African public universities through the establishment of research chairs with a long-term investment trajectory of up to fifteen years.

The main goal of SARChI is to strengthen and improve research and innovation capacity of public universities for producing high quality postgraduate students and research outputs. The key objectives are to:

• improve South Africa’s international research and innovation competitiveness while responding to social and economic challenges of the country;
• attract and retain excellent researchers and scientists;
• increase the production of masters and doctoral graduates; and
• create research career pathways for young and mid-career researchers, with a strong research, innovation and human capital development output trajectory.

Research chairs are held by a university in partnership with a public research institution (such as another university, a science council, a national research facility or an academic health complex). Since 2006, 150 research chairs have been awarded to 21 public universities across the country in the following sectors: science and technology for poverty alleviation, innovation, engineering and technology development, and within the national science and technology missions.

2. South African Maths Education Chairs Initiative
The MECI follows the same structure as SARChI in that research chairs are held by university professors whose research team comprises of PhD candidates and masters students. However, MECI is unique in that it combines both research and development components to ensure that the knowledge generated is converted to practical tools and programmes that directly address the maths crisis.

The MECI is a national intervention in mathematics education that focuses on improving the quality of mathematics teaching and learning. The Initiative intends to use the existing experience and expertise of the selected chairs to address the crisis that exists in mathematics education in South Africa. Since 2009, the initiative has been co-funded by the FRF with the Rand Merchant Bank (RMB) Fund (75%) and the DST (25%) to the total value of two million rand (R2 000 000) per annum, per chair, for a five-year period.

In total, six chairs working in four universities have been supported to date, with four of them focusing on secondary school mathematics and two focusing on primary school numeracy education. The chairs are as follows:

**Mathematics chairs**

• Professor Jill Adler (University of the Witwatersrand);
• Professor Marc Schafer (Rhodes University);
• Professor Werner Olivier (Nelson Mandela Metropolitan University); and
• Professor Cyril Julie (University of the Western Cape).
Numeracy chairs
• Professor Mellony Graven (Rhodes University); and
• Professor Hamsa Venkatakrishnan (University of the Witwatersrand).

The rationale behind MECI is to devise innovative solutions to address the national crisis of poor teaching and learning of mathematics in the public education system. It is envisaged that solutions lie in providing training and development for teachers and school leadership and through academic citizenship and public engagement in national and regional forums in the field of mathematics and numeracy education. Research reports and outputs are expected to yield sustainable and pragmatic solutions to improve the quality of mathematics teaching and learning, as well as learner performance.

Five-year targets for chairs
In order to assess delivery of the above objectives specific targets were set for the five year period. Annual outputs would be monitored to ensure that the chairs are on track to deliver on these targets. The programme has been designed in such a way that the chairs continuously review and reflect on progress in the field. This approach enables chairs to change or vary their approach in response to emerging challenges and incorporating the lessons learnt in order to achieve the stated objectives.

The targets are listed as follows:

• The development of a partnership with at least ten (10) selected public secondary schools for the duration of the project in order to develop and deliver successful formal in-service training of senior/leader mathematics teachers at the partnership schools. The secondary schools will be selected from a list of schools provided by the Department of Education.

• Annual increases of at least 10% per annum in the number of Grade 12 mathematics passes in each of the schools involved in the programme run by the chair on average.

• Annual improvements in the quality of the grade 12 mathematics passes in each of the schools involved in the programme run by the chair.

• Research reports on the research undertaken and the research outputs that point to sustainable and pragmatic solutions to improve the quality of mathematics teaching and learning as well as learner performance.

Two of the chairs will be completing their first five years of research and programme implementation at the end of 2014, while the remaining four chairs will be completing their first five years in 2015 and 2016.

Objectives for chairs
The six chairs had similarly structured goals. The distinguishing features are the level of intervention, which is either primary or secondary school; and focus, which is either numeracy or literacy. The generic goals are listed below:

• improve the quality of teaching of in-service mathematics educators at primary or secondary school level;
• improve the mathematics results (pass rate and quality of passes) in primary or secondary school as a result of quality teaching and learning;
• research sustainable and practical solutions to improve numeracy and literacy; and
• provide leadership in numeracy and literacy education and increase the dialogue around solutions for the mathematics crisis.

3.1 Wits Maths Connect – Secondary
The Wits Maths Connect Secondary is a five-year research and development project which aims to improve the quality of mathematics both in teaching and through the quality of learner performance in mathematics. The project, which ran from 2010 to 2014, is run by Professor Jill Adler. This programme supports ten secondary schools and one junior secondary school, and targets educators and learners from grades 9 to 12.

3.1.1 Activities
1. Improve quality teaching
Over the life of the project, more emphasis was placed on working directly with educators rather than directly with learners, and the original focus on the FET phase (grades 10-12) was extended to include lower grades. Below is a description of the project activities.

a) Developing Mathematical Judgement and the Content Focused Project
In the initial two years of the programme, two projects were piloted and implemented to focus on educators: 1) the Developing Mathematical Judgement (DMJ) project and 2) the Content Focused Project (CFP). DMJ was piloted in 2010 and started running in 2011. It was a professional development project which was school-based and aimed at improving the professional knowledge of mathematics educators. This was done through 10 workshops designed to focus on key mathematical objects of learning. The project also included school support for educators and the educators’ study of their own and each other’s lessons.

CFP was run from 2011 and was designed to complement DMJ; it focused on mathematical content knowledge for teaching specific concepts. CFP was originally designed as short mathematics courses addressing content of mathematics examinations papers 1, 2 and 3. The project also focused on the mathematics curriculum with the aim of enhancing educators’ capacity to support all learners including high achievers in mathematics and hence improve the quantity and quality of passes.

• Changes to the initial model
The chair’s intervention has evolved over the project life-cycle through a consistent learning and review process. Initially, the overarching goal of the chair was to strengthen the mathematics pipeline within schools as well as between schools and the university. During the initial two years of the project, it became evident that the grades 9-10 transition was a critical issue that needed to be addressed. Therefore in 2012, the Transition Maths (TM) courses were introduced. TM1 was targeted towards educators teaching grades 8, 9 and 10 and TM2 was designed to support educators teaching in grades 11 and 12, with the objective to help more learners obtain quality passes. Overall this change to the model resulted in a greater mobility of skilled educators across the GET and FET phase.

The educators who participated in both the TM1 and TM2 programmes were initially interviewed by the chair. The interviews involved educators completing specific tasks set by the chair to determine their content knowledge and teaching experience of mathematics. At the end of the programme the teachers were interviewed again in order to assess the impact of the programme on individual educators.
• **Transition Maths 1**

Transition Maths 1 (TM1) was introduced in 2012 to support a smooth transition for learners from grade 9 to grade 10 mathematics. It was observed that poor learner performance in mathematics in lower grades creates a backlog of mathematical competency. As a result, learners would struggle with the subject as they progressed to higher grades. The programme thus introduced the TM1 as a means of bridging the gap between GET and FET phases. It was envisaged that the programme would accomplish this by increasing the number of educators who are well prepared to teach at both levels of the transition in the project schools. This supports the project goal of having more learners taking mathematics in grade 10 and succeeding.

• **Grades 9 and 10 work programmes and common assessments**

The programme team together with educators in project schools developed work programmes and common exam papers at grades 9 and 10 levels. The initiation of work programmes was a response to the gap between grades 9 and 10 mathematics curricula, which has been exacerbated by the transition from the Revised National Curriculum Statements (RNCS) and National Curriculum Statement (NCS) to Curriculum Assessment Policy Statement (CAPS). The common assessment initiative provided an opportunity for educators in the project schools to participate in the setting and moderating of exam papers. In 2012, the project team and educators produced mid-year and final exam papers for grades 9 and 10 mathematics based on the project work programmes.

• **Transition Maths 2**

Research evidence and statistics from various universities indicate poor performance in tertiary programmes that require proficiency in mathematics. This situation obtains as a result of accumulated deficiencies in mathematics as learners move from lower to higher grades. In response to this challenge, the programme introduced Transition Maths 2 in July 2012; it focuses on the transition from school mathematics to university mathematics, particularly by helping educators to increase the numbers of learners obtaining A, B, and C symbols in mathematics in grade 12. TM2 is targeted at educators with previous experience of teaching FET mathematics who aspire to support and challenge their learners in aiming for higher marks. The course runs over 10 months and consists of eight two-day contact sessions and independent study between contact sessions.

2. **Improve quality learning**

a) **Learner Mentoring Project (LMP)**

The Learning Mentoring Project (LMP) was a pilot project, intended to run in 2011 and 2012 in three programme schools. The goal of the project was to support learners in improving their mathematics through an innovative mentorship model which involved undergraduate students who served as role models for the learners. The LMP aimed to create an informal context for mathematics learning with the structural functionalities of a second site of learning where mentors develop working relationships with learners. Mentors also challenged learners to think critically and creatively as mathematics problem solvers and created a safe environment for discussing, encouraging and challenging learners' academic ambitions.

As an intervention programme, LMP sought to change the tendency of learners in under-resourced township schools to depend solely on the educator as the source of teaching and learning, and thus to challenge learners to do more independent work.
The intention was to increase learners’ self-confidence in their mathematical abilities and to foster attitudes that lead to active participation in the classroom. To this end, the LMP was designed to encourage and support learners working on their mathematics, on their own, and with other learners, outside of class time, and particularly in doing and working on homework tasks.

3.1.2 Changes to the model

The chair’s intervention has evolved over the project life cycle. As described above, this is most notable in the shift from a sole focus on FET phase and matric results to include the transitioning process between phases (grades 8, 9 and 10). Initially, the overarching goal of WMC-S was to strengthen the mathematics pipeline within schools as well as between schools and the university. During the initial two years of the project, it became evident that the grades 9-10 transition was a critical issue that needed to be addressed. Therefore in 2012, the TM courses were introduced, TM1 was targeted towards educators teaching grades 8, 9 and 10, and TM2 was designed to support educators teaching in grades 11 and 12, with the objective to help more learners obtain quality passes. Overall this change to the model resulted in a greater mobility of skilled educators across the GET and FET phase.

3.1.3 Impact and lessons learnt

The chair has produced and shared 97 research outputs with local and international audiences, engaged in 13 collaborative research projects with other South African and international academics, and made 14 research presentations at conferences and other forums. The chair has also supervised a total of 42 honours, masters and doctoral students.

So far the chair has conducted 27 workshops and 4 TM courses reaching 156 educators. Some of the educators have reported improvements in their content knowledge, pedagogical skills, increased confidence, better ways of planning lessons and managing classroom time and a renewed love for maths and teaching as a result of these workshops and courses. All educators increased their scores on pre and post-tests in both TM1 and TM2 (8% and 7% respectively in 2013). Educators attributed the improvement in their quality of teaching to the opportunity that the programme created for them to collaborate with their peers in a community of learning.

Over the four years of available data, there was an overall increase of 15% in quality of matric passes and 70% of the schools demonstrated improvements in the matric passes from year to year. Grade 10 learners in participating educators’ classes outperformed their peers in a standardised test of learner gains. The educator training focus on transitions has meant that more GET phase students are better prepared for FET mathematics and matric learners are better prepared for university level maths.

Some of the lessons learnt include the following:

- Strong research methodology is required in order to demonstrate programme impact on the learners.
- Strong national and international research collaborations are beneficial to knowledge sharing and exposure to current methodologies, resources and knowledge.
- There is need to be responsive to educator and learner needs and challenges in order to address systemic challenges and bring about sustainable solutions.
- Building relationships and securing partnerships with schools is crucial in enhancing programme sustainability.
3.2 **Wits Maths Connect – Primary**
The Wits Maths Connect – Primary (WMC-P) is focused on foundation phase mathematics and aims to improve learner performance by increasing educator content knowledge, pedagogical skills and improving their attitudes towards the teaching profession. The numeracy chair’s work is based on the prevailing situation in which numeracy education has not been a priority and is under-researched. The chair is held by Professor Hamsa Venkatakrishnan, who will be completing her first five years in 2015.

The assumptions of this project are that by targeting educators, the learners will ultimately benefit through improved teaching. The belief is that this is a more sustainable solution as educators are being provided with the necessary skills and knowledge to continue teaching and influencing learners positively once the intervention has concluded.

### 3.2.1 Activities
The chair’s programme consists of four development focused projects which intend to address the issue of educator development. This chair does not have a learner-directed activity, and the impact on learners is expected to be seen over time.

1. **Professional development (mathematics teaching)**
   a) **Lesson Starters Project**
   The Lesson Starters Project (LSP) aims to impact on early number teaching and learning in the Foundation Phase. The LSP uses resources, artefacts and activities to assist educators in ideas for teaching lessons. Three workshops are run per year from across the Foundation and Intersen Phases, with educators’ classes ranging from grade 1 to grade 5. These workshops are done at the schools, as well as at the Wits Education campus.

   The project offers resources to participating teachers consisting of a pack of 15 minute starter activities aimed at developing learners’ early number strategies. So far the project has provided resources for Grade 2 (2011) and Grade 3 (2012), which are shared with teachers in workshops held during the year. The research team also carries out observations, including video taping of two starter activities implemented by each teacher in their classrooms. Educators are given immediate feedback after observations.

2. **Pedagogy and methodology (mathematical learning)**
   b) **Opportunities to Learn Maths (OTLM)**
   The Opportunities to Learn Maths (OTLM) is a 16-day course focused on developing mathematics content knowledge from a pedagogic perspective. The 16 days are split into eight two-day blocks across the year with eight half days for schoo-based work related to the course. It investigates building opportunities for educators to work on their own mathematics and to build a culture that normalises this activity as a professional expectation. Two to five educators per school, who teach Foundation and Intersen maths (ranging from grades 1-7), attend these workshops during the year. A pre- and post-test is done on the educators in order to assess changes in knowledge. The focus of this course is on educator mediation. There is also a mentorship aspect of the programme, where high performing educators act as mentors for their school and assist other educators.

c) **I Hate Maths (IHM)**
   The I Hate Maths initiative is a collaboration between the WMC-P project and the BEd Concepts and Literacy in Mathematics (CLM) course. It is focused on public advocacy and community building around primary mathematics. Two key strands are part of this initiative:
• a monthly primary maths-focused problem that is posted on the Wits maths chair website and sent out to Wits Education staff/students, an email discussion group, and to Educator magazine that is distributed to all schools; and
• a biannual, public I Hate Maths seminar.

This programme focuses on enhancing educators’ mathematical knowledge, but also extends beyond the boundaries, and aims to improve visibility and impetus to primary mathematics and provide openings for the building of networks and communities for primary maths educators who meet with the aim of enhancing their own mathematical knowledge.

3.2.2 Impact and lessons learnt
The chair has so far produced 38 publications with a research team of 14 researchers in contribution towards developing sustainable and pragmatic solutions to improve the quality of maths teaching and learning in the country. The chair also presented at 17 conferences.

To date 133 unique educators have participated in OTLM, LSP and the lesson starters study. The educators participating in the chair’s programme achieved a 13 percentage point improvement between pre- and post-test scores in both 2012 and 2013, and educators reported a positive attitude towards maths, improved skills and content knowledge, feeling more prepared and empowered to teach learners in maths and numeracy. With reference to improving learner performance 7 out of 10 schools had a 10% or greater improvement in grade 3 ANA scores from 2011 to 2012. All ten schools showed an improvement in the grade 3 Leverhulme pre- and post-test scores in 2012.

3.3 South African Numeracy Chair project – Rhodes University
The Rhodes University South African Numeracy Chair (SANC) under Professor Mellony Graven is implemented in 12 core and three peripheral primary schools in the Eastern Cape – in Grahamstown, the surrounding coastal areas and Alickdale. The SANC, now entering its fourth year, has established two interconnected communities of practice for numeracy teachers and numeracy education researchers. The approach of the SANC project is to address the intended objectives by organising and evolving, in collaboration with the Wits numeracy chair, platforms for scholarly discourse around improving early numeracy; building communities of researchers engaged in interventions to improve numeracy; and engaging with national policy in the area of numeracy.

3.3.1 Activities
The SANC project activities are split between research capacity building and outputs in the field of numeracy and development interventions informed by research. The research outputs are disseminated locally, regionally and internationally.

The Numeracy Inquiry Community of Leader Educators (NICLE) initiative, whose major aim is to build a passionate and engaged community of practice (COP) among the teachers, is the flagship community initiative in the programme. Launched on 30 March 2012, NICLE is a partnership where each teacher brings critical classroom experiences to bear on the project. NICLE focuses on the critical transition from Foundation to Intermediate phase (Grades 3 and 4). The rationale is that there is often little interaction between teachers in these phases and pre-service education is structured around phase specialisation. This often means that intermediate phase teachers know little about the teaching of foundational numeracy concepts.
This is a major problem as available evidence indicates that the majority of intermediate phase learners do not have the foundational concepts required to progress mathematically. Similarly foundation phase teachers know little about intermediate mathematics teaching and where their learners are heading.

The chair also ran after-school maths clubs as a second site of learning. The masters’ students being supervised by the chair also set up maths clubs for development and research. NICLE teachers also participated in clubs and there is growing interest in these clubs every year. The clubs offer benefits for learners to develop independence and resilience as well as test their ideas.

Other community-based initiatives aimed at creating a culture of interest in and excitement about mathematics include the Community Maths Buzz, family math events, field trips and regular articles in the local newspaper.

3.3.2  Impact and lessons learnt
The chair’s programme has produced 73 research outputs in three years, reaching a national and international audience which include 34 peer reviewed publications, 16 non-peer reviewed proceedings and five book chapters.

To date 143 unique educators have completed the NICLE programme. There are qualitative indications that the in-service educator training in numeracy and the distribution of complementary resources and materials are influencing educator attitudes and improving their pedagogic knowledge. There is also improved quality teaching evidenced by increases in numeracy content knowledge, amount of class-time spent on numeracy and more advanced operations (i.e. multiplication and division), amount of learner numeracy activity, achieved through increase in homework and number of sums assigned to learners.

There were improved numeracy scores on grade 4 Askew test, a sample of ANAs for grade 3 and grade 4 and the ‘4 operations test’ for grades 3 and 4. The provision of additional opportunities for learners to practice mathematics through homework books and maths clubs assisted in the observed changes in learners’ numeracy dispositions and ability.

The programme has provided researchers to test their findings in practical settings with learners via maths clubs. As a result of these activities practical learning products such as ‘How To’ guides, Holiday Fun booklets, homework books series and activity pages have been produced. Generativity and replicability of programme activities arising from Numeracy Buzz is promising for sustainability as already evidenced by maths club spin-offs.

The lessons learnt to date include the following:

• Building trusting relationships with schools and educators provided a conducive environment for all parties to collaborate and leverage on each other’s strengths.
• Continuous monitoring of the programme enables the chair and the research team to accommodate educator and learner needs, anticipate and address arising challenges.
• Community outreach programmes have enormous potential to increase community awareness and parental participation in numeracy activities.
3.4 FRF Mathematics Education Chair - Nelson Mandela Metro University

The South Africa Maths Education Chair at Nelson Mandela Metropolitan University (NMMU) targets grade 10 to 12 mathematics teachers and learners through a technology-blended model. The chair, Professor Werner Olivier, is working in ten secondary schools in the Port Elizabeth area. He will complete his first five years at the end of 2015.

The programme approach is two-pronged. The learner-directed components of the programme are implemented as a stop-gap solution to deliver urgent short term changes that will see learners empowered to achieve better marks. The teacher-directed components of the programme are expected to deliver a change in teachers, then in teachers’ practice in the classroom and consequently learner performance over the medium to long term.

3.4.1 Activities

The programme activities are modelled around improving the quality of teaching and improving the quality of learning as detailed below.

1. Improve quality learning

   d) Maths educator skills upgrade project (MATHSUP)/Mathematics skills upgrade (MSUP)

   MATHSUP is a one-year, accredited programme consisting of two short learning programmes (SLPs) for grade 11 and 12 educators. The SLPs are conducted with educators over holiday periods and are seven days in duration. The SLPs focus on the content of the curriculum as well as training and exposure to technology skills to teach maths (e.g. GeoGebra and the calculator emulator). Educators have been provided tablets and laptops equipped with the TouchTutor\textsuperscript{TM} mathematics support package and schools have been equipped with data projectors and screens.

   MSUP is a similarly structured programme targeting grades 8, 9 and 10 educators but is not accredited. MSUP was introduced in 2013.

   e) Community of practice

   The purpose of the COP is to create a professional development community of educators. Educators from the project schools meet as a group six times a year to discuss and share their experiences implementing the techno-blended teaching model. This is also an opportunity to distribute resources and provide training to educators. Classroom observations were planned as part of this model, but have not been implemented systematically due to capacity constraints.

2. Improve quality learning

   f) Top learner incubator school programme (ISP)

   ISP is a Saturday school programme for the three top learners from grades 11 and 12 in each project school. Learners attend the sessions over 16 Saturdays, which are hosted at NMMU. The programme is delivered jointly with the Engineering Department and is focused 50% on maths and 50% on science (about two hours per subject). Learners receive a tablet preloaded with the TouchTutor\textsuperscript{TM} package. In 2013, the programme was extended to all grade 10 maths learners.

   g) Peer support programme

   Peer support is a voluntary, structured after school session open to all grade 11 and 12 maths learners. The sessions are run by Top Learners, guided by video maths tutorials. The chair found that some schools hosted a structured session once a week, others met sporadically and in some schools the educators ran the sessions. It is expected that by the end of 2014 the chair will
redefine the peer support programme and potentially introduce learner workbooks to be aligned with the content video lessons.

For grade 10 learners, the peer support programme links Top Learners (with tablets) to a group of 2-4 peers. As all grade 10 maths learners have been provided with video aligned workbooks, it is expected that the top learners will work with their peers in a scheduled fashion.

3.4.2 Impact and lessons learnt
The chair has so far produced 12 research reports and has made over 70 presentations at seminars and conferences. The chair and the research team have produced five actionable, practical products produced for use in schools. The programme has so far been replicated six new districts and one new province (Free State) reaching an additional 872 learners and 469 educators with ISP and MATHSUP/MSUP, respectively.

To date, 546 unique educators have completed MATHSUP/MSUP (including those outside of the 10 FRF schools). The use of technology has sparked an interest in educators and there evidence of uptake and use in classrooms. Similarly, the introduction of GeoGebra has contributed significantly to changing educator pedagogy and behaviour. Learners have reported a positive attitude towards maths indicating improved skills and content knowledge. Seven of 10 schools had a 10% or greater improvement in the number of learners passing maths. Another 7 out 10 schools had a 10% or greater improvement in the number of quality passes. Furthermore, 5 out of 10 schools saw a 10% increase in their matric maths pass rate with 53 learners being awarded bursaries for further study in maths and science.

Some of the lessons learnt to date include the following:
• Strong leadership and administrative capacity are critical in ensuring the success of programmes.
• Building partnerships and relationships with other stakeholders is vital in increasing the reach of the project in order to benefit more teachers and learners
• When properly introduced and implemented, technology can enhance skills transfer and greater knowledge acquisition.
• Complementary teaching resources and materials of a superior quality can greatly support the up-skilling to educators.

3.5 FRF Mathematics Education Chair – University of Western Cape
Professor Cyril Julie is the FRF Mathematics Education Chair at the University of the Western Cape in Cape Town. The project was started in July 2012 and will finish in 2016. Professor Julie works with ten secondary schools targeting educators in the FET phase and learners in grade 10 only. The chair’s programme, Local-Evidence Driven Improvement of Mathematics Teaching and Learning Initiative targets grades 8 to 12 mathematics teachers through a unique model. The programme aims to enhance and improve teaching by basing it on the analysis of current, actual classroom teaching practices and conditions at classroom, school and educational department level.

3.5.1 Activities
1. Improve quality teaching
h) Workshops
The programme runs professional development workshops for educators from the ten project schools. These workshops occur throughout the year from January to November and consist of two hour contact sessions with educators after school. Workshops focus on strengthening content knowledge
and skills of educators. Content which is covered during the workshops is identified through other activities of the project as well as through feedback from educators.

i) Extended teacher institutes
The extended teacher institutes run in conjunction with the workshops and is identified by the chair as being equivalent to seven workshops. The institute is a breakaway session held over a weekend from Friday evening to Sunday afternoon. Similarly the institutes aim to strengthen the content knowledge and skills of educators and allows for focused and directed activities. Each planned activity is commonly run by a member of the R&D team and topics include: solving mathematical problems, working with mathematical software such as GeoGebra, as well as development of educator skills to plan and prepare for the completion of the curriculum.

j) Co-teaching
The programme provides in-school support to participating educators and their schools; this involves retired maths educators who act as mentors, support, and fieldworkers for the project. Their roles in-school vary according to the needs of the schools, they work across grades and with many different educators and assist by gathering information and feedback as well as co-teaching. Co-teaching involves the fieldworkers helping educators plan and teach maths lessons, additionally fieldworkers will teach a lesson as an exemplar for the educators.

2. Improve quality learning
k) Winter School
In 2014, the programme began a winter school programme for learners. This programme ran during the mid-year school holidays and included learners from three of the project schools. This is initial work which will contribute towards the plan for implementing learner directed activities.

l) Learner study guides
Learner study guides have been developed and published as a resource for learners. After piloting these guides, the chair decided that they needed more work and is currently researching ways to improve the guides before distribution.

3.5.2 Changes to the model
Significant changes to the model have taken place since the theory of change document was developed in 2012.

m) Model extended to grades 8 and 9
The chair identified that one of the key issues in only working with grade 10, 11 and 12 educators is that learners entering the FET phase have weaknesses which have not been addressed in the GET phase. The chair is working to scaffold a basic maths foundation in grades 8 and 9 so that learners who enter grade 10 have stronger mathematical content knowledge and are more equipped.

n) Educator focused activities
In the original theory of change, the chair stated that he would be working with learners and educators. Thus far, all activities have been educator focused. Learner activities will be implemented in the second half of this project. According to the chair, the focus on educator activities results in a more sustainable outcome which intends to build the quality of teaching among the maths educators that will, in turn, have a long-lasting effect on learners. Additionally, the model requires a synergy between what educators do in classroom and what extra provision is available for learners. The project has now reached a point where they can address this and work with learners in the low achievement bands.
3.5.3 Impact and lessons learnt
Forty four (44) unique educators and 105 participating educators have been reached during the course of the intervention. The programme has been effective in providing training to educators, complementing it with relevant resources to aid implementation and skills on the use of teaching strategies. There appears to be high educator interest in the programme workshops, institutes and dialogues that take place throughout the year. To date, the programme has been successful in offering 15 workshops and 8 institutes from 2012 to 2014. Educator attendance at the workshops and institutes has increased year-on-year, in terms of repeat attendance. Furthermore, the percentage of educators attending more than 50% of the sessions has also increased each year, from 52% in 2012, to 66% in 2013 and 89% in 2014.

Participating educators reported that the learners have responded positively to the spiral revision sessions at the beginning of each class. A common challenge which was raised by the educators was learners’ inability to retain information over a long period of time. Educators reported that spiral revision has allowed them to overcome this challenge and that knowledge retention has improved since building it into their lesson plans.

While maths educators are the direct beneficiaries of the programme, learners are the ultimate beneficiary. Impact is thus determined by learner improvements. To some extent the benefits to educators are translating to learner impact. There was an overall 9% increase in the number of learners passing matric maths for the ten project schools from 2012 to 2013. Five of the ten project schools had an increase in the number of learners passing Maths with four of these five schools increasing the quantity of learners passing by 10% or greater. Five of the ten project schools saw an increase in the number of quality matric maths passes from 2012 to 2013, all with a 10% or greater increase. Three of the ten schools had an increase in their matric maths pass rate with one of these schools improving their matric maths pass rate by more than 10% from 2012 to 2013.

3.6 FRF Mathematics Education Chair – Rhodes University
The FRF Mathematics Education Chair is a five year research and development project which aims to improve the quality of mathematics both in teaching and through the quality of learner performance in mathematics. The project was started in 2010 and 2014 is the last year of the initial five-year funding period. The project is run by Prof. Marc Schäfer and supports ten secondary schools in the Grahamstown district. It targets educators in the Further Education and Training (FET) phase (grade 10-12) and learners in grade 10 only.

3.6.1 Activities
1. Improve quality teaching
   a) Mathematics Teacher Enrichment Programme (MTEP)
   The MTEP is the core of chair’s work. MTEP offers sustained professional development of teachers that include mathematics content, mathematics teaching for conceptual understanding, development and use of resources for effective teaching and learning, and In-School Support for the teachers. MTEP is run throughout the year during term time and is offered in two hour sessions every two weeks at Rhodes University. In 2014, the chair has explored also delivering MTEP in full-day sessions. In addition, there are in school classroom support visits during the weeks in between contact sessions and there is an annual, weekend maths retreat.

   Educators are provided with appropriate teaching resources and materials at the MTEP sessions to take back into classrooms. Furthermore, resource support is also being researched for effectiveness by the research team. Examples of resources include: wooden cubes, Geoboards, A0 Cartesian Plane posters, VITALmaths, GeoGenius, Calcdoku puzzles and GeoGebra.
p) In-School Support

In-School Support workshops support MTEP and take place in schools. The rationale for the In-School Support was to support educators in their classroom practice. In-School Support has taken the form of additional, on-site training in various skills (Equations Editor in MS Word and GeoGebra to create worksheets and test papers) support for educators’ professional identity and growth (supporting to prepare papers and presentations for AMESA Congresses) and resource support (teaching aids and tools) to create an ‘ideal classroom’.

A facet of In-School Support is learner benchmark testing. Since 2010, all grade 10 to 12 maths learners have been tested using the chair’s benchmark test. The test is based on previous year’s content and thus tests gaps in learners’ content knowledge which the chair calls the backlog. The benchmark test indicates specific backlog areas which then directly inform the MTEP sessions as well as the content of Catch-Up sessions.

However, benchmark testing is not only tied to Catch-Up. All grades are tested to fully understand the performance backlog of learners as they progress from grades 10 to 12. The chair’s research into the backlog not only informed the content of MTEP sessions, but has concretely influenced the future design of the programme to address geometry in grades 8 and 9. Benchmark testing revealed significant and compounding backlog in learners’ spatial understanding.

q) VITALmaths

The VITALmaths project is a collaborative project with the Teacher Education University North West Switzerland. The project has produced and disseminated 44 short video clips that develop mathematical themes and support mathematical exploration. The videos are on average two minutes long and can be downloaded in English, isiXhosa and German. The videos utilise common household objects (e.g. rubber bands, matchsticks) and can be used as preparation aids for maths lessons or as activities for learners to support concepts. The videos can be accessed online via YouTube, Facebook and the MTEP website; the videos can also be accessed via smart phone by navigating to these sites.

r) GeoGebra

GeoGebra is a critical component of the MTEP and In-School Support foundation. GeoGebra is free, open source mathematics software. Users create interactive geometry, algebra, statistics, and calculus applets. The animations help with visualisation of complex maths concepts. Educators can make their own applets or choose from the tens of thousands of applets shared through the online community.

Four schools received a week long GeoGebra intervention by Prof Reinhard Hölzl, Head of Mathematics Department, University of Teacher Education Lucerne. Additionally, four In-School Support workshops were held in 2013 and open to all educators in the school (not just MTEP participating educators).

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8 Additional funding from the Swiss South African Joint Research Programme and the NRF supports the VITALmaths project.
2. Improve quality learning

s) Catch-Up

Catch-Up is the key learner directed activity. Catch-Up provides two hours a week of after-school maths support for grade 10 learners. The sessions are taught by experienced educators many of whom are retired and contracted to the chair’s project. Apart from helping learners to catch up on their mathematical knowledge, the project aims at freeing time for teachers in normal classes to concentrate on teaching the current content properly.

t) Maths Olympiad

The Rhodes University Maths Experience (RUME) is an annual Maths Olympiad for the Grahamstown community that attracts over 300 learners from grades 7 to 12. The purpose of the Maths Olympiad is also to identify talented learners and encourage them to continue with mathematics. MTEP has collaborated with RUME to sponsor learners from the MTEP schools to participate. Since 2012, 177 learners on average have participated annually. The chair’s staff provide learners with Olympiad training on a regular basis, participate in the setting and marking of Olympiad question papers and coordinate logistical arrangements. Educators are also involved in the marking of papers.

3.6.2 Changes to the model

The programme has undergone several changes as compared to the initial design in 2010.

u) Addressing the maths backlog

Catch-Up was not initially conceived as part of the programme. Benchmark testing was conducted to determine gaps in learners’ content knowledge to inform the MTEP sessions; however it soon became clear to the chair that a learner intervention was needed. The chair found that a substantial amount of educators’ time was spent on backlog content. Utilising retired, but experienced educators the Catch-Up offering was formalised in 2011 whereby community-based educators were leveraged to address the maths backlog in the FRF schools.

v) Model extended to grade 8 and 9

After the five-year period, the chair plans to shift the model’s focus to the GET phase to grades 8 and 9. After working in the FET space for five years, the chair feels that greater gains will be reached by working with learners in grades 8 and 9 because the content gap is already so great in grade 10. The chair’s research also supports this shift and is supported by educators, school principals as well as district officials. For example, key research is trying to find the root of key special issues for learners which may be beginning in grade 8 and 9. The chair plans to introduce a maths club and peer tutoring model and also work with GET educators in the second phase of funding.

3.6.3 Impact and lessons learnt

On average 25 educators participate in MTEP annually and 83 MTEP sessions have been held to date. A core cohort of 10 educators participated in MTEP for four years. There is evidence of improved attitudes, mathematical repertoire and changed behaviour.

The matric maths pass rate in the 10 FRF schools increased from 33% in 2010 to 56% in 2013; surpassing the Eastern Cape provincial average by 13%. The total number of learners passing matric maths increased on average by 12% and total number of quality passes improved by more than 10% per year 2010-2013. From 2010 to 2013, the average matric maths mark improved from 17.3% to 29.8%. Appreciative Inquiry participants reported that Catch-Up has made maths accessible, increased confidence and made them hopeful of their maths future. Learners are practicing more maths with 1 900 hours of after school maths support.
The chair has come up with innovations in conceptual and strategic teaching, developed VITALmaths video clips and produced 96 research outputs (considered to be in the top 10% of researchers at Rhodes University). Currently the chair has five ongoing research and development affiliations and seven collaborations with other institutions.

Some of the lessons learnt to date include the following:

- Regular educator evaluations and learner benchmark testing are critical in informing programme design.
- Sustained educator motivation and participation of a core group of educators were influential in improving the performance of the programme.
- Supportive leadership, highly dedicated and qualified research and development team are required to guarantee programme success.
- Creating close relationships with schools and gaining the trust of educators enables smooth implementation of the programme.

4. **Emerging lessons from maths education interventions**

Two of the six chairs have completed their first five years of the programme and the remaining four are due to complete theirs in 2015 and 2016. End-term evaluations have been conducted for the two chairs while mid-term evaluations have been conducted for the other four.

The purpose of these evaluations is to provide programme funders, programme administrators as well as the chairs, an independent, overall assessment of the chair’s project to date. The evaluation considered the chair’s inputs, outputs, outcomes as well as any indications of impact on learners who are the ultimate beneficiaries. The mid-terms also served as an opportunity to document changes to the chair’s model, as well as challenges faced by the programmes. The primary audiences for the mid-term evaluation reports are the funders as well as the chairs. It is intended that the results of the mid-term evaluations will be used by the funders to determine the agency of the chair’s programme on five dimensions: relevance, effectiveness, impact, sustainability and cost. Further, as a developmental evaluation, the purpose is also to provide feedback to the chairs to inform programme development.

Evaluation findings indicate that positive lessons have been learnt over the duration of the programmes’ implementation.

Emerging results from evaluations across the chairs indicate the following:

- Reports on both the maths and numeracy chairs indicate significant changes in teachers’ pedagogical skills and improvement in their subject knowledge in numeracy and mathematics.

- Overall, the number of learners writing mathematics has decreased but the number of learners passing Grade 12 maths with 50% and above has improved. For example, Prof Adler’s schools improved learner passes by 25% between 2010 and 2013, while Prof Julie reported a 272% increase between 2012 and 2013.

- Overall, the chairs are affiliated to a broad range of academic bodies which provide them with platforms to share their experiences and learn from their peers. Given the number of conference presentations the chairs have made, they are definitely playing a leading role in increasing the dialogue around mathematics education. For example, between 2010 and 2013 Prof Schafer and Adler have made 62 and 36 conference presentations, respectively. Prof Graven had 35 conference presentations between 2011 and 2013.
The following specific lessons and observations have been made regarding the chairs’ initiatives:

a) Significant improvement in learner academic outcomes were recorded during the course of the chairs’ development interventions, although this fell short of the set 10% annual increase in the NSC examinations in mathematics. However, evaluation findings have indicated that the 10% target was an aspirational target, rather than one which could realistically be achieved.

b) There is significant statistical evidence suggesting that the chairs and their teams have produced enormous volumes of research papers and outputs during the course of implementing their programmes. For example, two of the chairs have produced 97 and 96 research outputs over the period of five years, respectively. All the chairs have presented their research papers at various education seminars and conferences. However, it has been noted that research without development work will not be of use to schools. There is need for academics and researchers to translate their findings into development projects which can feed back to schools.

c) Teachers are normally under enormous pressure from the education system to cover the prescribed mathematics curriculum in their respective schools, and this is often achieved at the expense of learners’ understanding of critical mathematical concepts. This is what leads to the creation of backlogs in learners’ knowledge, thereby culminating in poor academic performance in the subject. It was suggested that the chairs should balance the need for teachers to cover the curriculum while helping them to acquire the critical teaching skills and content knowledge of mathematics not immediately related to what they have to teach.

d) Leveraging partnerships to enhance programme delivery and sustainability is crucial. It has been observed that where the chairs have established cordial relationships with schools and gained the trust of educators programme implementation often seem to run smoothly. Building effective partnerships with other stakeholders increases the likelihood of mobilising resources to support programme implementation in the long term.

e) Teacher development programmes must have performance measurement mechanisms to measure changes in teacher content knowledge, pedagogical skills and the academic performance of learners that they teach. Too often teacher development programmes are assessed on attendance and completion rates.

f) Finally, it was noted that the dominant mode used by most chairs to deliver development initiatives to the target teachers involved face-to-face support to teachers through workshops, classroom observations, mentoring and coaching. While these may suffice, more creative methods of reaching and engaging with teachers are required to maximise the impact of the programmes. For instance, there is evidence that the use of information communication technology (ICT) to facilitate delivery of programmes is empowering for the both the educators and learners.
Going forward

Given the lessons learnt over the five years of the programme’s implementation, there is a need for robust advocacy to be embarked upon with key policymakers and funders to influence the course of mathematics teaching in the country. However, in order to accomplish this effectively, the chairs should start working on packaging their tried and tested teaching and learning resources to enable these to be disseminated and used by other teachers who are not participating in the programme. In addition, rigorous analysis of mathematics teaching and practice on the ground should continue to be strengthened and documented in order to inform policy and practice.

The programme should also increase the focus towards adaptation of research findings to classroom practice. Research insights have to be tested and more direct intervention on learners should be prioritised to increase the probability of higher impact on learning outcomes. More engagement with government is necessary to facilitate scaling up of successful teaching approaches and methodologies.