In the Implementation of NCS: How is Instructional Capacity in Mathematics Teaching and Learning Constructed, Organised, and Replenished in a Secondary School?

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Abstract
This article discusses what constitute instructional capacity in mathematics teaching and learning in a secondary school, with focus on the instructional behaviours and practices. The questions that guided the research are: What is the level of the instructional capacity of mathematics teachers? How do mathematics teachers identify, mobilise and activate resources for mathematics instruction? What challenges or otherwise do mathematics teachers experience in the process of developing the instructional capacity? What contribution(s), if any, do students, principals and curriculum advisors make in the development of the instructional capacity? Data were gleaned through document analysis; classroom observations of 10 grade 12 mathematics teachers; face-to-face semi-structured interviews with 40 students, 10 teachers, 10 principals from 10 public secondary schools in Vhembe District (Limpopo, South Africa) and 5 mathematics advisors. There were observable differences in the capacity to encourage reform practices within different schools, high performing schools were relatively way ahead of low performing schools in terms of encouraging reform-oriented teaching and learning. This implied that school’s capacity for instruction is both the individual teacher and the organisational components, resources upon which instructional capacity is built are variable and multifaceted, and schools should identify, define and deploy accordingly its share of resources to shape and preserve capacity for instruction.

Key words
Instructional capacity; Quality instruction; Instructional culture; Instructional programmes; Instructional leadership; Instructional unit; School’s capacity; Low Performing Schools (LPS); High Performing Schools (HPS).

1. BACKGROUND AND RESEARCH QUESTIONS
The singularity of mathematics as a school subject which, on the one hand, is compulsory in most educational systems world-wide (e.g. Zimbabwe), and , on the other hand, has the most infamous reputation for being difficult to learn, yields some unique phenomena. South Africa in 2006 introduced a National Curriculum Statement (NCS) designed, among others, to encourage more student involvement in the learning of conceptually demanding subject matter across the various grade levels in order to improve pass rates. However there are schools in Malamulele West Circuit (MWC), Vhembe District, Limpopo that continue to struggle and falter in their attempts to provide such quality instruction to their students in mathematics as reflected in low pass rates in high stakes examinations as shown in Table 1.
Table 1: MWC November-December 2008 and 2009 Matriculation mathematics examination Analysis.

<table>
<thead>
<tr>
<th>% Marks</th>
<th>0-29</th>
<th>30-39</th>
<th>40-49</th>
<th>50-59</th>
<th>60-69</th>
<th>70-79</th>
<th>80-100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of students</td>
<td>2008</td>
<td>179</td>
<td>55</td>
<td>36</td>
<td>18</td>
<td>11</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>2009</td>
<td>220</td>
<td>63</td>
<td>20</td>
<td>10</td>
<td>9</td>
<td>4</td>
<td>2</td>
<td>328</td>
</tr>
</tbody>
</table>

Of concern then is why our schools continue to fail in their quest to improve the teaching and learning of mathematics, which in turn impacts on student performance. The emerging research questions became:

- What is the level of the instructional capacity of mathematics teachers?
- How do mathematics teachers identify, mobilise and activate resources for mathematics instruction?
- What challenges or otherwise do mathematics teachers experience in the process of developing the instructional capacity?
- What contribution(s), if any, do students, principals and curriculum advisors make in the development of the instructional capacity?

2. **THE CONCEPTION OF CAPACITY**

There have been attempts to find possible solutions to the problem of the teaching and learning of mathematics with a view to improving the “opportunities-to-learn” for all students, especially those that have been historically marginalised and ill-served by the education systems (for example, Floden, Goertz, & O’Day, 1995). The problem has often been defined as a “capacity problem” by Floden, et al. (1995). According to Floden, in comparing differentially resourced schools, the resource differential often defines what is meant by “capacity”. Where this conception of capacity fails to hold, is when we compare schools with similar resource base that nonetheless, offer instruction of different qualities and/or have markedly different student achievement level. I therefore argue that, among others, the ability to offer quality instruction in mathematics is determined not only by the presence or absence of particular resources, but also by the construction and organization of such resources and their use by the various school participants, their maintenance and/or replenishment. That is, capacity for instruction involves identifying, mobilizing and activating particular sets of resources to achieve the specific goals of instruction in mathematics within the school.

3. **THE NOTION OF CAPACITY FOR INSTRUCTION**

The study is premised on the notion of “capacity for instruction” as a framework for bringing together, in a dynamic way, the investigations of “classroom processes” and “the school wide organizational resources and arrangements” that are set up to promote quality teaching and learning. The conception of capacity, in the latest work on teaching and learning research by Corcoran and Goertz (1995), is something more than just “the power or ability of an individual or an organization to do some particular thing”. This new conception underlies its attraction to research and development work on school quality and improvement. According to this new conception of Corcoran and Goertz (1995), a school’s
capacity includes, among others, five key dimensions (framework for instructional capacity) that are likely to shape instruction and learning in a school.

3.1 The framework for instructional capacity

3.1.1 The individual teachers
Teachers constitute one important dimension of a school’s capacity for instruction (Wiliam, 2008). It is not only the presence or absence of the teachers that makes a difference, but the teachers who are “competent in content, pedagogy and assessment” of their subject area (Stronge, 2007).

3.1.2 Instruction culture of school
The organisational culture of a school is defined by the “nature and content of the professional community” at the school, the “collaborations” among staff members, “collective and shared goals” for teaching and learning of mathematics at the school and the “opportunities for students and staff to exert influence” of the teaching and learning at their school (Newman, King, & Youngs, 2000).

3.1.3 Instructional programmes of the school
In many instances, schools often differ from each other based on the “quality and coherence of their instructional programmes” (Heck, 2007). The coordination and focus around clear and specific learning goals collectively by the mathematics staff within the school define what I have called the instructional programme of the school.

3.1.4 Instructional leadership of the school
Leithwood et al. (2006), claims that leadership explains about 5-7% of the difference in student achievement across schools. The closer leaders are to the core business of teaching and learning, the more likely they are to make a difference to students’ achievement levels (Robinson, 2007:21).

3.1.5 The quality and quantity of technical and/or material resources
Such resources as “staffing levels”, “instructional time”, “class size”, “manipulatives” and other (scientific) equipment are critical material resources that impact on the teaching of mathematics in a school (Heck, 2007). The capacity to deliver quality instruction depends not only on the individual teachers’ intellectual and personal resources but also on their interaction with, among others, specific groups of students, colleagues at school, subject area committees, the curriculum and materials developed by others (Cohen & Ball, 1999: 3). Framed in this manner, and focusing on the five dimensions discussed earlier on, instructional capacity becomes a useful concept for investigating the construction of quality instruction because of the way it draws attention both to the “classroom and the school-wide effects”.

4. METHODOLOGY
I have argued that, among others, the ability to offer quality instruction in mathematics is determined not only by the presence or absence of particular resources, but also by the construction and organization of such resources and their use by the various school participants, their maintenance and/or replenishment. The study therefore sought to
establish ‘capacity for instruction’ as a phenomenon that allows schools to offer quality instruction in mathematics teaching and learning. However, people act according to the meaning of things and persons to them; their reality is socially constructed (Krathwohl, 2004). From this viewpoint, it was necessary to see the school’s instructional capacity through the eyes of the actors to establish the purpose of those people’s behaviours. I, therefore, examined “capacity for instruction” in a number of bounded units, including the “teachers and teaching”, the “students and learning”, “curriculum and physical resources”, “organizational leadership and institutional culture”. Therefore, this was achieved by adopting a descriptive survey design.

4.1 Research Design

Using a descriptive survey design employing qualitative research techniques allowed me to explore the phenomenon among a number of systems and sub-systems where the common characteristics and the differences both had a voice. The term “qualitative” denotes not only a technique of gathering and analysing descriptions of a phenomenon, but also a point of view about reality – individual’s perceived reality (Krathwohl, 2004). This approach was chosen because it allowed me to understand the situation better as understood by the research participants. In fact, in my conception of this study, “the context” was a critical component of the phenomenon that I sought to establish. Focusing on 5 LPS and 5 HPS, as measured by pass rates in high stakes examinations in Vhembe District, I investigated how these secondary schools as units constructed and made sense of their roles as implementers of the new curriculum and what practices they then generated out of these interpretations to result in a particular configuration of capacities. I went further, however, by acknowledging and seeking to establish the reality that observed practices were not only a function of the individuals involved, but they were also shaped by the material conditions, especially the structures and cultures, of the organizations within which they found themselves. I made no assumptions about the similarities and/or differences in the construction and development of capacity for instruction within the entities that I studied. In fact, I conducted this investigation precisely to establish “the commonalities” and “the unique features” of instructional capacity as it was constructed and practiced in the ten selected schools.

4.2 Site selection

According to McMillan and Schumacher (1993: 411) choosing a site is a negotiated process to obtain freedom of access to a site that is suitable for the research problems and accessible for the researcher in terms of time, mobility, skills and resources. In the study I chose ten (10) public secondary schools in Vhembe District in Limpopo Province of South Africa, on the basis of socio-economic status, educational attainment based on the achievement levels of grade 12 students in mathematics in the 2008-9 matriculation examinations, ethnic composition, location and accessibility.

4.3 Purposeful sampling

Purposeful sampling according to McMillan and Schumacher (1993:413) involves choosing samples on the basis of being likely to be knowledgeable and informative regarding a particular phenomenon. The target population for the study, therefore, included FET band mathematics students, practicing secondary school mathematics teachers, principals and mathematics curriculum advisors whose perceptions were valuable to the study. A
purposively selected sample consisted of 40 grade 12 mathematics students, 10 principals, 10 grade 12 mathematics teachers, (all from 10 secondary schools) and 5 mathematics curriculum advisors (3 from circuits and 2 from district).

4.4 Data collection
The qualitative research approach provided a broad description of observations and field notes investigating the level of the instructional capacity of mathematics teachers, the challenges the mathematics teachers experience in the process of developing the instructional capacity, and the contribution(s) students, principals, HoDs and curriculum advisors made in the development of the instructional capacity. Although my unit of analysis was schools in Vhembe District, the research programmes were designed to capture the multi-dimensionality of the concept of capacity. The instructional culture, the instructional leadership, the instructional programmes, the teacher’s instructional practices and quality and quantity of technical and/or material resources of the ten selected schools, were examined as a basis for establishing what constitute instructional capacity in mathematics teaching and learning. The whole project therefore involved a number of contributory sub-studies that focused on one or more of the issues I raised in the research questions. For example, my approach to answering the question: How do mathematics teachers identify, mobilise and activate resources for mathematics instruction, involved designing a research on teachers and teaching mathematics in schools and classrooms; a research on students and learning mathematics in schools and classrooms; a research on curriculum implementation or the enacted curriculum; a research on schools as institutions (with a culture) for learning mathematics; and finally a research on school leadership for quality mathematics instruction. This approach underscores the importance of the format and activities in the initial phase of the study which included piloting, reading and developing a conceptual understanding of the study.

4.4.1 Data Collection Techniques
Data was collected using a deliberate mix of methods such as interviews, observations, and document analysis. In collecting the data, I was guided by the following principles that I developed in the framework on capacity for instruction:

4.4.1.1 The first principle
I have advanced the premise that instructional capacity is multidimensional. It has both the individual and the social or organizational components (Corcoran and Goertz, 1995). At the individual level, I needed to investigate such resources as were contributed by the teachers, students, and the physical materials and intellectual tasks (curriculum subject content) within mathematics. Beginning with the teachers, I wanted to get at such issues as teachers’ knowledge and skills; their dispositions to content, to the students and towards innovation in general; and their sense of self as teachers and as lifelong students of mathematics. In terms of techniques, interviews and lesson observations were used to a large extent. For the students, I wanted to probe their dispositions to the subject matter, to the teaching and learning processes, their engagement with teaching and learning, and their sense of self as students of mathematics. I used focus group interviews and lesson observations. Finally, it was important to get a sense of the physical resources or materials available for instruction in mathematics, e.g. textbooks, manipulatives, and other facilities available for learning. How these are organized and used to construct a school’s capacity was the more crucial issue I wanted to understand with this component. Document analysis and lesson
observations and interviews were used for this. Materials, in the Cohen and Ball (1999) sense however, also include the intellectual materials i.e. the tasks, the problems and the discourses through which content is represented in a particular classroom. I wanted to get at the notion of what mathematics means in the particular classrooms and schools and how that adds or subtracts to each school’s construction of capacity for quality instruction. Lesson observations, document analysis (including samples of students’ work) and interviews were appropriate.

4.4.1.2 The second principle
I have also argued that capacity is not fixed but dynamic. It is constructed and reconstructed at the point of interaction between the three components of the instructional unit. That is, capacity is constructed differently in each classroom as the teacher interacts with a particular group of students around the materials and as the students interact with each other about the content. This variability in capacity was captured through a thorough observation of the classroom processes in mathematics at the schools.

4.4.1.3 The third principle
Coupled to the classroom aspects of the study, I focused also on the social or organizational effects and arrangements that shape up capacity to create quality instruction in mathematics. This included the subject department, staff networks within the school, networks with other schools and higher education institutions, organization of time or scheduling, organization and use of physical materials, and most importantly the school leadership for instruction. Lesson observations, document analysis and interviews were appropriate.

4.4.2 Validity and reliability of instruments
How can a researcher be sure that the data gathering instrument being used will measure what it is supposed to measure and will do this in a consistent manner? This is a question that can only be answered by examining the definitions for and methods of establishing the validity and reliability of a research instrument.

4.4.2.1 Reliability in data collection instruments
In this study, to ensure that other researchers in similar studies, using the same methods of data collection and analysis obtain results that closely resemble results obtained in the study; I considered the following strategies as suggested by McMillan and Schumacher (1993:386):

   a) Researcher’s role
   In this particular study it implied that I was a teacher in the same district where the selected schools were found, I already had a social status within the group which posed a threat to the reliability of the study. I thus ensured that preconceived ideas and knowledge did not result in bias regarding the interpretation of research data. This was achieved by corroborating the findings by means of tape recorders, literal transcription of participants’ responses and quotations from documents.

   b) Informant selection
   To ensure that future researchers contact informants similar to these I have contacted in this study, informants are described as SGB members, mathematics curriculum advisors,
principals, grade 12 mathematics teachers and students from public High schools in Vhembe District in Limpopo Province.

c) Social context
I described the social context in terms of time, people or place to help in data analysis.

d) Data collection strategies
In the study the process entailed interviews, observation and document analysis. I then matched the statements from respondents with the information on biographical questionnaires, evidence from documents and observational records. Finally, the statements were checked for consistency with the theoretical framework established earlier.

e) Data analysis strategies
Data analysis involved developing units then categorising the unitised data by grouping them around phenomena discovered in the data (which were relevant to research) and then group categories to form patterns.

f) Analytical premises
Literature was studied from which prior research findings which informed the study were noted so as to be integrated or contrasted.

4.4.2.2 Validity in data collection instruments
Content validity is a measure that I used to assess the validity of data collection tools (Peat, 2002). During the developmental stages of the research instruments, I asked three principals (who themselves are former mathematics teachers) to check whether the research instruments covered all areas of the research questions before piloting them. Before the implementation of the adapted research instruments after piloting, they were appraised (checked) by two recognised experts in mathematics education.

4.5 Data Analysis
Data analysis occurred simultaneously with data collection, in order to inform further collection of relevant data (Miles and Huberman, 1994). The creation of analytic memos from the interviews and lesson observations at each school and/or theme(s) formed an important strategy for capturing emerging themes and categories and helped to focus the coding and further collection of data during the study. More importantly, these analytical memos also formed the basis for on-going conversations with other experts in the area of instruction, learning, leadership, school quality and school reform in general.

4.5.1 Findings from observational data
As discussed earlier, to understand capacity one has to get insights on the terrain as a whole, and then focus on the specifics of mathematics. My specifics in this case relate to the provision of mathematics at FET levels of schooling. That is, the schools’ capacity for mathematics instructions at the FET level. Spending a day at each of the ten schools, I was treated to some of the most interesting instructional practices and subject oriented discourses in the classrooms, especially from the high performing schools. Quite a few things I observed made for an interesting story about instructional capacity in mathematics in secondary schools. In the next section I highlight some of these key features of instructional practice in mathematics at the observed schools.
4.5.1.1 Instructional practices in mathematics at the ten study schools

In my attempt to profile some of the instructional practices in mathematics in the selected study schools, I describe a pattern of classroom practices that helped me to characterise the schools’ capacity for instruction in mathematics. I specifically focus on some of the observed practices and discussions with the ten teachers I observed and interviewed during my visit for data collection at each school. It is worth noting that interviews were also conducted with students and school principals during the school visits to get a broader view of things at each school.

4.5.1.1.1 Reform practices and strategies

The classroom observations focused on the way in which the teachers used any of the specific practices that are associated with the reform-oriented practices enshrined in NCS, such as co-operative learning, problem-solving relevant to real life situations, student engagement in hands-on activities and so forth. In the ten observed lessons, I noted that all the five teachers, where the quality of instruction is perceived to be good as measured by the high pass rates in mathematics matriculation examinations, did engage with some of the reform practices that are being advocated by the reformers (see EXTRACT 1 from classroom observations below).

4.5.1.1.2 Student Engagement

My observations in the classrooms also focused on student engagement. I wanted to find out if there was time during the lesson when a significant number of students seemed engaged and also to find out what it is that they were engaged in and for how long as well as what they were encouraged to do. Most specifically I focused on the following aspects of the students’ involvement: Debate/discussion (whole class or in small groups), answering of the questions from the teacher, standing up and write on the board, solving problems in small groups or individually, etc.

4.5.1.1.3 Classroom discourse

My data collection plan also involved paying attention, during the classroom observations, to the issue of who talks, and to whom during the lesson as well as the role played by the teacher. In almost all the lessons observed at the five high-performing schools, the teachers directly involved and elicited responses and ideas from the students and there was no deviation from this pattern of teaching. The EXTRACT 1 from classroom observations below (transcription 1) provides evidence of a fairly exciting reform oriented mathematics instruction.

EXTRACT 1: School-1

The school-1 is situated in a small but expanding village. It had an enrolment of 603 students. T1 has been teaching mathematics for 8 years and has been teaching at this school for 6 years. He holds a teacher’s diploma and an ACE. The school had a class of 19 grade 12 mathematics students in 2011. The performance pass rates for grade 12

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5 The ten teachers involved in the study were coded according to the school number, from 1-10.

6 Advanced Certificate in Education (ACE), NQF level 6 in the HEQF (equivalent to a 1st Degree)
mathematics for the past three years of the school were 70%, 68.4% and 69.6% in 2008, 2009 and 2010 respectively. T1 was working on the lesson on trigonometry and I learnt from the teacher that students were revising the two methods (Pythagoras theorem and trigonometric ratios) of solving right-angled triangles done in grade 10 in preparation for the solution of problems in two or three dimension. In the lesson, students were asked to work on the following problem in pairs: In the diagram, ABCD is a straight line. Given that, \( CE = \frac{BD}{2} \), find the value of \( \cos y \). Transcription 1 is a part of this lesson.

**Transcription 1**

Lesson on trigonometry (March 2011)

T1 Read the question carefully. \( CE = 3EF \), what does this mean?

\[ \begin{array}{c}
\text{T1} \\
\text{Then, we have } 3EF = \frac{BD}{2}. \text{ How do we solve this problem?}
\end{array} \]

\[ \begin{array}{c}
\text{T1} \\
\text{Correct, } \frac{BD}{2} = 3EF. \text{ Now, these are } 3EF, 4EF \text{ and } 5EF. \text{ We use Pythagoras Theorem.}
\end{array} \]

\[ \begin{array}{c}
\text{T1} \\
\text{How do we find } \cos y?
\end{array} \]

\[ \begin{array}{c}
\text{T1} \\
\text{This is } \cos \text{ so, adjacent divided by hypotenuse.}
\end{array} \]

\[ \begin{array}{c}
\text{T1} \\
\text{Again, how do we find } \cos y?
\end{array} \]

\[ \begin{array}{c}
\text{T1} \\
\text{CE = 3EF, 3 + 1 = 4. So, CF = 4EF. } 3EF = \frac{BD}{2} = BC. \text{ The sides of the right-angled triangle BCF are 3, 4 and 5 by using Pythagoras Theorem.}
\end{array} \]

\[ \begin{array}{c}
\text{T1} \\
\text{So, } \cos y = \frac{3}{5}
\end{array} \]

\[ \begin{array}{c}
\text{T1} \\
\text{Ana, what is your final answer?}
\end{array} \]

\[ \begin{array}{c}
\text{T1} \\
\text{cos } y = \frac{3}{5}
\end{array} \]

\[ \begin{array}{c}
\text{T1} \\
\text{Can you explain to the class how you get it?}
\end{array} \]

\[ \begin{array}{c}
\text{T1} \\
\text{BC = 3EF, CF = 3EF + EF = 4EF, by applying Pythagoras Theorem to triangle BCF, BF = 5EF, cos y = adjacent divided by hypotenuse = } \frac{3}{5}
\end{array} \]

S1 explained the solution to S2 and S3. She reorganised her understanding and explained in a more understandable form to S3. She improved further her explanation to the class. Hence, the responses from students evolved from brief phrases or single disconnected sentences to explanations which make sense to all. Now the teacher puts the whole burden on students to explain and justify their solutions, as well as to comment on the contributions of other students. The teacher allowed the students to explore by themselves the mathematical ideas and gave them the time to think, calculate and to provide answer.

In contrast to the above described pattern of teaching, teacher-talk dominated most of the observed lessons in the five low-performing schools, even though students had some knowledge of the content that was being taught. Following is **Extract 2** from classroom
observations (transcription 2) of low-performing school that would serve to illustrate a pattern that I saw throughout my classroom observations of the low-performing schools with regard to how the teachers taught the mathematics content to the students.

**EXTRACT 2:** School-6

School-6 had inadequate classrooms and had a class of 68 grade 12 mathematics students in 2011 with an enrolment of 753 students. The performance pass rates for grade 12 mathematics for the past three years of the school were 34.9%, 22.4% and 19.1% in 2008, 2009 and 2010 respectively. **T6** had a teacher’s diploma and 4 years teaching experience. The teacher was working on the lesson on solving quadratic equations. Transcription 2 is part of this lesson.

**Transcription 2**

Lesson on solving quadratic equations (January 2011)

**T6**

Given \( ax^2 + bx + c = 0, (a \neq 0) \)

The solutions to the quadratic equation (1) are

\[ x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \quad \text{... (2)} \]

Through a teacher-dominated style of class discourse, the teacher copied two examples from the memoranda on to the board with the students copying in their exercise books. Thereafter three quadratic equations from past examination papers were written on the blackboard for students to do on their own following the examples given. **T6** moved around comparing what students were writing with what was in the memorandum. Time never permitted the teacher to prompt students to report-back their solutions to the class. However, it could have been proper for **T6** to first recall the methods that students have used to ‘solve quadratic equations’ before (method of factorisation and method of completing the square). After that, ask the students to solve an equation like \( 2x^2 - 3x + 4 = 0 \) by the method of completing the square because factorising is not possible and then let the students attempt to find the solutions to (1) (in terms of a, b, and c) by completing the square (leading to the quadratic formula for solving all quadratic equations in real number set). When I asked **T6** in **EXTRACT 2** why his lesson was teacher-dominated and why he taught quadratic equations in January 2011 (content done in grade 11), he said:

“...I could not complete this content in 2010... On the other hand and to be frank with you, actually we as teachers normally try to encourage active participation from students since it is something that has been emphasised by our Department...But, somehow, I think because of the time factor, we teachers end up solving the problems for our students in order to cover all the content....”

Most of the teachers who engaged in teacher-dominated style of discourse expressed the belief that when they have limited time, covering the content efficiently must take precedence over student learning with understanding (like in **EXTRACT 2**). This assertion simply indicates that these teachers were unable to maintain the “tension” between simultaneously covering the content and attending to student understanding.

**4.4.1.1.4 Role of teacher**

My classroom observations of the five high-performing schools depicted a pattern, with respect to how the teachers taught the content to the students, consisting of the following phases:

1. whole-class discussion,
2. pair work,
3. Reporting-back, and
4. Summing up

In **EXTRACT 1**, **T1** held a whole-class discussion facilitating students’ understanding of the problem and coming with possible heuristics and strategies for a solution. Pair work was the second phase that provided a chance for the students to solve a problem themselves through active discussions. At the third reporting-back phase, students were given an opportunity to explain and justify their solutions to the class. **T1** would summaries the lesson by actively discussing the solution and justifying the legitimacy of the solution. This approach could not only foster the development of the students’ conceptual understanding, but also enhance their awareness of the strategies and thinking disposition (NCTM, 2007a). I observed that offering clarification usually occurred during the whole-class discussion and the reporting-back phases. The main aim was to get the students to understand the activity thoroughly, to generate possible strategies for a solution and to amplify students’ explanations.

### 4.5.2 Findings from interviews data

The goal of the interviews was to establish how schools as institutions integrate resources (be they physical resources, human resources, learning and teaching support materials, etc) to result in a particular configuration of capacity to promote high achievement levels of grade 12 students in mathematics. Interviews were conducted with a teacher and a sample of four students at each of the ten schools after lesson observations. Interviews were also held with all ten principals and five mathematics curriculum advisors before classroom observations. Some important themes that emerged from the interviews included: adequate system of control; professional development of mathematics teachers through lesson study; instructional and organizational coherence; alignment of capacity building in mathematics teaching and learning.

#### 4.5.2.1 Adequate system of control

Control in school is the principal’s means of checking whether the work is done (Bush et al., 2009). Controlling teachers’ work would entail the principal to use the observation of classroom teaching and analysis of learning outcomes to elevate school-wide instructional practices and implement strategies that promote professional growth and reflection, with special focus on new teachers (Bush et al., 2009). However, when asked how principals build instructional capacity in mathematics teaching and learning in the area of teachers’ knowledge, skills and disposition, the following were some of their responses:

**P1**

‘...Class visits is one way of discovering teachers’ knowledge, skills and disposition, which may inform professional development of that teacher and I don’t have staff at my school that say; ‘no do not come to my class’...”

**P6**

‘... The noble thing to do is to sometimes establish direct observation of teacher teaching, but teachers’ unions said we are not allowed in classrooms. So as a result, I always make sure that teachers and students are in their classrooms and assume teaching is taking place and that the teacher has the knowledge and knows how to dish his content.”

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7 The ten principals involved in the study were coded according to the school and given a number from 1-10.
With respect to the type of support teachers received from principals or HoDs, one teacher had this to say:

T9: “... We are let down by our promotional policies here... there is no clear cut way of assessing whether teachers are indeed teaching when they are in class besides depending on the test scores (which are often bad) of the controlled common assessment tasks from the district offices... as a result students are pushed to the next grade without meeting the laid down criteria...”

In such circumstances, to support teachers as they develop new instructional skills in mathematics teaching, and as they try to integrate a commitment to quality instruction with the demands of high-stakes testing, an adequate system of control is imperative.

4.5.2.2 Professional development of mathematics teachers through lesson study

Any development means change. So if we talk about professional development, what is it that we need to change? Studies of teachers’ attempts to change their practice suggest that the capacity to teach in new ways is also connected to teachers’ views of self, to their beliefs about their role in classroom activity, and to the persona they adopt in the classroom (Fuhrman, 1994). What then is the situation (type of workshops) that we have to create to bring about change in mathematics teaching and learning? Typical of teacher’s comment was:

T1: “… Mathematics is a practical subject. So listening to a presenter from one of these Universities will not improve how we should teach the subject... In my view, we should workshop ourselves... by which I mean, to the topics that are said to be problematic, there are classroom teachers who have the knowledge of these topics and I would like them to teach the topic while other teachers observe and learn and then afterwards open a discussion with the help of the university presenters... that way teachers will learn far much better.”

Lesson study is a teaching improvement and knowledge building process which originated in Japan (Ono et al., 2007). Lesson study allows the teachers to realise that there is something wrong with their current teaching practices and can even inspire teachers with the sense that they can succeed with content and methods that initially seemed foreign to them. The essence of lesson study is that teachers plan lessons collaboratively and then the lesson is taught by one of the teachers while observed by the other teachers and discuss the lesson.

4.5.2.3 Instructional and organisational coherence

As instructional leaders, principals give greater attention to working with teachers to coordinate the school's instructional programme, solving instructional problems collaboratively, helping teachers secure resources, and creating opportunities for in-service and staff development (Bush & Glover, 2009). The basic issue is one of determining at which point, in schools, leadership should be exercised in order to ensure both their existence and organisational survival (requiring social control) and organisational progress (requiring individual or group development) (Bush et al., 2009). Typical of teachers’ comments regarding instructional and organisational coherence were:

T8: “...Principals should avoid enrolling so many students where there are few classrooms resulting in classes being overcrowded for their own selfish ends..., a notch in their salaries.”

T9: “...There is too much or unparalleled focus on grade 12 as compared to grade 8, 9, 10 and 11. Extra teaching for content coverage is only done for grade 12, why? ...as a result students move to grade 12 with uncompleted content of
Thus, the core purpose of principalship is to provide leadership and management in all areas of school (e.g. student distribution in class, ensure that students who enter next grade below proficiency receive mathematics skills support, consider student work and teacher recommendations when assigning students to do mathematics, etc) to enable the creation and support of conditions under which quality teaching and learning takes place (Bush et al., 2009). The use of unqualified teachers to teach mathematics at grades 8 and 9 is very popular in the low-performing schools as compared to high-performing schools. The principals were aware of this shortcoming in their deployment practices of teachers as evidenced by one principal’s comment:

P7: “...No one would advocate for non-qualified mathematics teacher to teach mathematics. However, I cannot leave students without a teacher to attend to them. When teachers leave, mostly through redeployments as a result of dwindling enrolment or for whatever reason, I play the ‘substitution game’...I mean I just assign any teacher with fewer periods to help teach mathematics.”

This type of organisational decision does not support any school’s instructional goals and neither does it support students learning needs, and should be avoided at all costs.

4.5.2.4 Alignment of capacity building in mathematics teaching and learning

Due to accountability pressures, teachers opt for providing students with the necessary skills by working out problems similar to those that are in the past examinations papers (the case of EXTRACT 2). The modes of pedagogy in classroom then rely heavily on the transmission of knowledge model (see EXTRACT 2). In the under-performing schools, the use of memorandum-chalk-and-talk method was very common and there was little inclination towards reform-oriented pedagogical techniques such as cooperative learning environments where students are encouraged group work, discussions, reasoning, questioning, and communicating skills, the case of EXTRACT 1. Furthermore, teachers complained about too much focus on grade 12 when it comes to remedial intervention strategies, as one teacher lamented:

T9: “…There is too much or unparalleled focus on grade 12 as compared to grade 8, 9, 10 and 11. Extra teaching for content coverage is only done for grade 12, why? ...as a result students move to grade 12 with uncompleted content of previous grades, hence low achievement levels of students in mathematics matriculation examination...”

Therefore, our remedial interventions should cater for all grade levels other than grade 12 only. Another worrying factor is the unproductive use of mathematics memorandum by teachers and students as reflected by student’s comment regarding the use of mathematics memorandum:

S20: “…The mathematics memorandum is not doing any good to us as students because we tend to memorise the workings of questions in the memorandum but it’s not all... During examination time it becomes difficult to attempt most of the questions...”

The advantage of the mathematics memorandum, as a learning and teaching support material, would be the use by students to refer to it after they have worked out the

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8 The forty students involved in the study were coded according to the school and given a number from 1-40.
questions from the past examination papers. In the same vein, as a teacher one cannot teach copying the workings from a memorandum. Both teachers and students need to develop a skill of solving problems not a skill of following what someone has already done to solve the problem. Hence, students and teachers should avoid the edge of checking how mathematics problems are worked in the memorandum before they work the questions themselves.

5. CONCLUSION
Teachers constitute one important dimension of a school’s capacity for instruction. However, teacher effectiveness is an individual resource that varies across classrooms within schools, as well as a collective resource that varies across schools (Heck, 2009). Hence, how we conceptualise teacher effectiveness should reflect a balance of the instructional practices of teachers that both enhance teaching and curriculum-based assessments of students learning (Heck, 2009). The teaching of mathematics at the five high performing schools emerged as relatively ahead of the five low performing schools. However, in EXTRACT 1, I wished to illustrate the degree of engagement in the lessons. I noted that students were involved in various ways including debate/discussion (the whole class), and answering questions from the teacher. Despite the fact that the lessons went on smoothly, it was rather difficult to ascertain if all students had understood. However, in my post observation conversations with the T1 and T3, they underscored that, besides checking the student’s class and homework books, they often gave the students a weekly test which helped them to figure out if they (students) had understood. In EXTRACT 2, no effort was made to engage students during the presentation of the lesson or thereafter. Apart from that, copying from the memoranda to the board gave the impression that the teacher struggled with Pedagogical Content Knowledge (PCK) – the notions of helping students understand the concepts and ideas.

Each school has its own social structure and tends to organise instruction according to the prevailing local conditions (instructional culture). The fact that school-1 and school-6 were situated in close proximity to one another implied that the schools catered for the same communities and were impacted by the same societal factors. The great difference in student performance, however, suggests that the teacher competent in content, pedagogy and assessment in mathematics, the way the students were distributed in classes, the class sizes, and the promotional culture of the school made a difference in student performance.

6. DISCUSSION
In my presentation of instructional practices in previous section, I focused on some of the key features of what described the teaching and learning of mathematics at the ten selected secondary schools. My discussion has illustrated what appear to be the differential strengths in schools’ capacity to teach mathematics. Based on the data, I suggest that while the teachers in different schools worked hard to incorporate many aspects of the reform practices and sought to engage all students in some meaningful discourses about the key concepts in mathematics, there were observable differences in the capacity to encourage such teaching and learning within the different schools. Furthermore, while there were some important challenges in the way mathematics was approached (the use of mathematics memoranda by both teachers and students at the low performing schools), it
was evident that the high performing schools were relatively way ahead of the low performing schools in terms of encouraging such reform-oriented teaching and learning practices across their schools. How then do I make sense of the two key findings of the study: viz. that the LPS continue to struggle and falter in their attempts to provide such quality instruction to their students in mathematics as reflected in my discussion? To understand the (de)construction of capacity at the LPS, I examined the data with respect to the five dimensions of my framework for defining the “capacity for instruction”. The classroom observations revealed that in some schools teachers used the memoranda to present content to students and I have coined the practice “the memorandum-chalk-and-talk method” of imparting knowledge. In essence, most of the observed individual teachers struggled somewhat with the issue of how best to present and engage the students meaningfully with the mathematical content taught. A simple and more common explanation for such finding with respect to teachers’ struggle with Content Knowledge (CK) and more especially with the Pedagogical Content Knowledge (PCK) of mathematics would tend to focus on the teachers’ qualifications and/or teaching experience (Heck, 2007). More commonly, the less qualified and/or experienced a teacher is, the more pronounced the struggle with CK and PCK is likely to be (Heck, 2007). In the case of school F, however, the teacher was appropriately qualified and had teaching experience, it is not clear how such an explanation could by itself begin to account for the observed low pass rates in mathematics at the school. However, the organisational culture (instructional culture) at the LPS was not defined by a fairly high degree of collaboration among the mathematics teachers and, worse still, with other subjects in teaching parallel material and other pertinent factors. While being guided by the provincial and national curriculum guidelines, in terms of what and when to teach in mathematics, the teachers teaching at LPS appeared to exercise some degree of autonomy with respect to what to do, how and when to do it in their own mathematics classrooms. Therefore, the classroom processes remained a black box for principals at these LPS because of the substitution of professional approach to teaching with the unionist approach which hinders HoDs and principals from lesson observations. As a result students would move to the next grade with unfinished contents. So, while there were some limitations in each of these dimensions of capacity at these LPS, they (dimensions of capacity) provided powerful explanations about the capacity for instruction at the LPS.

My data suggest that the construction of the school’s capacity for instruction at these LPS, since the inception of NCS, could not have been treated as a once off event but rather a process that have to take place over a number of years. From my data analysis, I was able to link the deterioration of mathematics results in these LPS more directly to the loss of human capacity (with the requisite knowledge, skills, and experience) in mathematics and the way the students were distributed in classes, the class sizes, and the promotional culture of the schools. Apart from that, teachers’ exposure to the demands of NCS was limited to general guidelines offered by the teachers’ manuals, such as work-schedules and assessment plans, and a short period of professional development workshops that sought to acquaint teachers with the new content in the curriculum. It would appear that replacing or replenishing the capacity for instruction is much more than a substitution game where any teacher can just as easily replace another. Building a capacity for instruction involves bringing in appropriately qualified and skilled people for the specialisations that may have been left open, inducting the person into the school’s instructional culture, and developing and
deploying him/her appropriately for maximum performance in his/her subject area. This has, to date, been the biggest challenge at the LPS. When mathematics teachers leave for whatever reason, the principals of the LPS had to play the dangerous substitution game without the luxury or benefit of deploying teachers in the subject areas where they are appropriately qualified. It is this substitution game that I believe accounts most for the observed deconstruction of the LPS’ capacity for instruction in mathematics. That is, without the benefit of being able to replace (replenish) each mathematics teacher who leaves the school with another who may be deliberately recruited to fit the profile of the vacancy, the LPS has had to play an impossible game of substitution that leaves them with glaring gaps in mathematics and inappropriate deployment of resources. Such a game, unfortunately, has serious implications for the schools to offer quality instruction in mathematics.

7. IMPLICATIONS FOR PRACTICE
The findings from the study have several important implications for my broader understanding of the issues associated with the instructional capacity in mathematics in secondary schools. One important implication is the idea that a school’s capacity for instruction in mathematics is defined more accurately in terms of both the individual teacher and the organisational components. In the cases of schools F to J, for example, while the schools assigned non-qualified mathematics teachers to teach mathematics, the instructional culture in mathematics, the workloads, the interactions and other dynamics in the organisation cannot be rebuilt that easily. In such a scenario, constructing a school’s capacity thus has to do with more than just having a complete staff complement, but also includes such intangibles as the instructional culture, development and deployment practices at the school.

A second implication from my analysis is that resources upon which instructional capacity in mathematics is built are variable and multifaceted. While monetary and other physical resources often come first in my thinking about building the instructional capacity in mathematics of a school, the case of schools F to J begin to illustrate a very important place of “student-as-a-resource” for instructional capacity in mathematics. Students bring with them some background knowledge, skills, motivations, attitudes and goals to the learning processes of a school (Earnest et al., 2008). In South African context, where students have the freedom of electing mathematics, are not required to pay school fees, and also determine the post-provisioning and resource allocation by the government to schools, their place in shaping the character and quality of instructional capacity in mathematics in a school is very clear. Without the students in the right numbers in class (teacher-student-ratio), a strong promotional school policy in place, and all else that students bring with them to school, it is very difficult to imagine the existence of an instructional capacity in mathematics in a school that enhance student performance in mathematics. In this regard, Karsenty et al. (2007) asserted that students who arrive at the secondary schools with a history of constant failures in mathematics usually withdraws from further efforts to learn and succeed in mathematics but suitable learning environments which emphasise students’ points of strength, allow many of them to create sound mathematical products. A careful and systematic analysis and description of school resources to include other intangible resources is therefore important.
A final implication from this analysis is that **individual schools should identify, define and deploy accordingly its share of resources to shape and retain capacity for instruction in mathematics**. As illustrated by the case of school F, it is not just the presence or absence of a particular set of resources that is important in defining a school’s instructional capacity in mathematics but also how these resources interact with other resources and practices (or culture) of the school.

### 8. REFERENCES


