NAMIBIA COUNTS

STORIES OF MATHEMATICS EDUCATION RESEARCH IN NAMIBIA

MARC SCHÄFER, DUNCAN SAMSON, BRUCE BROWN
Editors
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Mathematics and mathematical ways of thinking are fascinating aspects of human consciousness. Our desire to make sense of the world around us through number has led to mathematics becoming a critical component of economic, social and technological endeavour. Within the context of an increasingly globalised and interconnected world, the importance of Mathematics, Science and Technology Education takes on particular significance. These sentiments are echoed in Namibia’s national vision which sees as its ideal an integrated, unified and flexible education system capable of delivering high quality education in order to prepare Namibian learners for an evolving global environment. Within this educational vision, particular emphasis has been placed on Science and Mathematics.

The purpose of this collection of papers is to provide a smorgasbord of recent research conducted in Namibia in the field of Mathematics Education. The intention is not to provide a comprehensive review of Mathematics Education research but rather to provide a series of detailed snapshots that represent the thoughts and contextualised research interests of recent Namibian Masters students. The book also contains introductory chapters that characterise the broader Namibian terrain from socio-economic and educational perspectives. Taken as a whole, this book thus provides a revealing glimpse into the varied issues that teachers and other education practitioners are grappling with on a daily basis.

The articles in this book reflect a commitment to professional growth at a local level as well as constructive engagement at a broader, national level. As such the various chapters of this book provide a rich resource to teachers, teacher educators, policy makers, academics and researchers. It is our hope that this book not only creates a platform to share and disseminate quality research but that it also provokes critical reflection and healthy debate, thereby contributing to the broader educational imperative of the Namibian national vision.
THE NAMIBIAN SOCIO-ECONOMIC LANDSCAPE

ROBERT KRAFT

Introduction
This chapter provides an overview of the Namibian socio-economic landscape. It argues that an appreciation of the features of that landscape – its natural and other economic resources, population, economy, social indicators, the main socio-economic goals and challenges of the society – is essential for educational researchers, planners, managers and teachers to understand in order to design and deliver their individual educational contributions to the development needs and challenges of Namibia.

The Namibian social and economic statistics and reports are regarded as of an excellent quality by most observers, the UN and its agencies. This chapter presents information on current indicators, statistics and conclusions from reports produced by: the Namibian National Planning Commission, the Namibian Reserve Bank, the World Bank, the International Monetary Fund, KPMG Namibia, the Government of Namibia’s Ministry of Education, Ministry of Labour and Social Welfare, and the Namibia Statistics Agency, and from the Stellenbosch University Research on Social and Economic Policy (RESEP) unit, with additional information from other sources. All provide quality social and economic information that is easily understood by the non-specialist.

National and Regional Government
Namibia, which achieved its independence in 1990, is a secular, democratic and unitary state. It is headed by a president with a division of powers between the Executive, Legislative and Judicial branches of government.

The Executive power of Namibia is vested with the President and Cabinet. The President is head of State and government and is elected by
direct franchise in a national election every five years. The Cabinet consists of the President, the Prime Minister, Deputy Prime Minister and a number of Ministers appointed by the President. A full range of national Ministries such as Finance, Education, Defence etc. and Commissions report to the Ministers or the Prime Minister.

The next level in this structure is organized administratively into 13 Regions (Figure 2) and subdivided into 131 constituencies. Each constituency votes for one councillor for the regional council of each region. There are 13 regional councils. Each region is headed by a Regional Governor with fairly extensive delegated authority granted the Regional Councils and the Governors to administer a range of national services. A 14th Region is in the process of being established with the splitting of Kavango into Eastern and Western Kavango.

Geographical areas

The Namibian landscape consists of five geographical areas: the Central Plateau, the Namib Desert, the Great Escarpment, the Bushveld, and the Kalahari Desert. Each has its distinct abiotic conditions (i.e. the non-living chemical and physical factors in an eco-system) and vegetation with some variation within and overlapping among them.

The wide and flat Central Plateau, the largest landscape formation in Namibia, running from north to south, is where the majority of Namibia’s population and economic activity occurs. Windhoek is located here. Namibia’s Coastal Desert, one of the oldest deserts in the world, stretches along the entire coastline and varies in width between 100 to hundreds of kilometres. The Great Escarpment which rises to over 2,000 meters is rocky with poorly developed soils, but is still more productive than the Namib Desert. The reason for this is that the summer winds bring moisture and rain. The Bushveld is in north eastern Namibia along the Angolan border and in the Caprivi Strip, now called Zambezi. It receives significantly more precipitation than the rest of the country, averaging about 400 mm per year. Adjacent to the Bushveld in north-central Namibia is the extraordinary Etosha Pan. The Kalahari Desert, shared with South Africa and Botswana, has a variety of localized environments ranging from arid sandy desert, to areas unlike the usual description of a desert such as the Succulent Karoo, home to over 5,000 species of plants, nearly half of them endemic: (Namibia. Government of Namibia - www.gov.na, 2014a; Namibia Cardboard Box Travel Shop, 2014; Info Namibia, 2014).
8000 \text{ km}^2 \text{ or only 0.97\% of Namibia land area is arable land, while agricultural land was 388,050 \text{ km}^2 \text{ or 47.14 \% of the land area in 2009.}} The FAO defines arable land as land the under temporary crops, temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded. Agricultural land is the land area that is arable, under permanent crops and under permanent pastures (Trading Economics, 2014a; Trading Economics, 2014b; Worldstat info, 2007).

Productive economic activity of some kind is already a feature of all these geographical areas of Namibia (see discussion of the economy later). But the challenges and opportunities of each geographical area for human habitation and sustainable economic activity vary greatly. What economic activity may suit one area may not be the best option for another.

### Population

Namibia is a large country of 824,292 \text{ km}^2, but for its size has a notably small population of only 2,182,852 (July 2013 est.) resulting in a population density of a mere 2.6 persons per \text{ km}^2 – one of the least densely populated countries in the world. By contrast its neighbour South Africa, with an area of 1,219,090 \text{ km}^2, has a population of 52,981,991 (July 2013 est.) producing a population density of 43.5 persons per \text{ km}^2. (CIA, 2014)

**Figure 1: Population growth in Namibia, 1921-2011**

The population of Namibia has grown steadily since 1921 (Figure 1), rising from approximately one-quarter million in 1921 to 1.8 million persons in 2001 to 2.1 million in the 2011 census, of which 51 percent were females and 49 percent were males.

Figure 2: Namibia 2011 population and number of schools by region

The regional distribution of the population (Figure 2) in Namibia is skewed with almost two-thirds of the population living in the northern
regions and less than one tenth of the population living in the south. This distribution has been significantly shaped by the distribution of rainfall, arable and agricultural land. The small overall population in Namibia is mirrored by the relatively small number of schools. In 2011 there were 1,703 schools countrywide, with 605,627 students and 23,039 teachers and educators.

But despite rapid urbanisation Namibia is still mainly a rural society with 58% of the population living in rural areas and 42% in urban areas (Namibia. Government of Namibia –www.gov.na, 2014b). This urban/rural pattern is not unusual in the earlier stages of industrialization. South Africa is more urbanised with 62% of its population in urban areas. Highly industrialized societies such as the USA, the United Kingdom and Germany have 82%, 80% and 74% respectively of their populations in urban areas.

**Selected social Indicators**

The data shows that over the past two decades Namibia has made significant progress in some of the key social welfare indicators but much still has to be done.

**Poverty**

Using household consumption expenditures as a welfare indicator a comprehensive report on poverty in 2012 by the Namibia Statistics Agency showed that the average *per capita* expenditures at constant 2009/2010 prices rose from N$556.21 in 1993/94 to N$1067.88 in 2003/2004 and then to N$1288.07 by 2009/2010, which showed that average income rose by 232% in real terms over the 17 years (Namibia Statistics Agency. 2012, p. 8). However, the average income figure does not tell the full story, as the majority of the population is still below that average income level.

Compared to the poverty line we see that the numbers in poverty are still large. Namibia’s *monthly per capita* poverty lines in 2009/2010 (Namibia Statistics Agency, 2012, p. 10) were:

- Food poverty line N$204.05
- Lower bound poverty line: “severely poor” N$277.54
- Upper bound poverty line: “poor” N$377.96

In 2009/2010 about 29% of the population still lived below the poverty line compared to the massive 69.3% living below the poverty line in
1993/1994. This is 9% points fewer that in 2003/2004 and 41% points fewer than in 1993/1994; a really significant improvement.

But it is also noteworthy that the ‘poverty gap’, which shows how far an individual is from the poverty line, has also been declining. The poverty gap was 28.1% in 1993/94 but had dropped to 8.8% in 2009/2010, which means that on average income had moved upwards and closer to the poverty line.

Looking at the geographic location of the poor, we see that the poor are disproportionately located in rural areas. “People in rural areas are twice as likely to be poor compared to those in urban areas with about 37.4 percent of people living in rural areas being poor compared to 14.6 percent in urban areas” (Namibia Statistics Agency, 2012, p. 12). Rural areas saw a huge decline in poverty from 81.6% to 37.4% or 44.2 percentage points, over the 17 year period, while the urban areas on average saw a decline of about 24.3 percentage points.

Figure 3: Regional poverty levels, 2003/2004 and 2009/2010

Looking at the incidence and changes of poverty by administrative regions we see big differences. For example, in Kavango the incidence of poverty is at over 50% while in Erongo and Khomas it is less than 10%. The declines in poverty also vary greatly between regions. For example, Khomas, where Windhoek is located, poverty declined from 26.8% in 1993/1994 to a mere 8.1% in 2003/2004 before it increased again to 10.7% in 2009/2010. While in Ohangwena region the poverty incidence declined dramatically from 89.2% to 30.1%.

**Education and poverty**

Taking the entire Namibian population aged 15 and above, about 13% do not have any formal education, 27% have primary education, 27% secondary education and 6% have attained tertiary education (2009/2010 estimates) (Namibia Statistics Agency, 2012, p. 21).

Educators and parents would be impressed seeing actual Namibian numbers confirming the well known effect of education reducing poverty. The effect in Namibia is truly dramatic. Table 1 shows poverty by educational attainment of household heads. It shows that the incidence of being poor declines as educational attainment rises.

**Table 1: Poverty incidence by educational attainment, 1993/94, 2003/04 and 2009/10**

<table>
<thead>
<tr>
<th>Educational Attainment of Household head</th>
<th>1993/94</th>
<th>2003/04</th>
<th>2009/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>No formal education</td>
<td>86.2</td>
<td>60.9</td>
<td>45.8</td>
</tr>
<tr>
<td>Primary education</td>
<td>79.5</td>
<td>44.6</td>
<td>34.3</td>
</tr>
<tr>
<td>Secondary education</td>
<td>45.3</td>
<td>18.6</td>
<td>16.6</td>
</tr>
<tr>
<td>Tertiary education</td>
<td>18.7</td>
<td>1.7</td>
<td>0.6</td>
</tr>
<tr>
<td>National</td>
<td>69.3</td>
<td>37.7</td>
<td>28.7</td>
</tr>
</tbody>
</table>

In 2010 about half or 46% of people without any formal education were poor, but about one third of those with primary education were poor. Obtaining tertiary education substantially lowers a person’s likelihood of being poor to almost zero, with only 0.6% of those with a tertiary education being poor. But, as noted earlier, because of improved economic conditions and other factors at work, poverty has declined among all educational groups since 1994.

**Employment/Unemployment**

The number of employed people declined between 2004 and 2008 but then rose from 331,444 in 2008 to 630,094 in 2012 or by an impressive 298,650 persons or 90% in 4 years. Conversely, broad unemployment increased between 2004 and 2008 from 36.7% to 51.2% then declined to 27.4% in 2012.

**Table 2: Basic indicators from Namibia Labour Force Surveys since 2004**

<table>
<thead>
<tr>
<th>Basic Indicators</th>
<th>2004</th>
<th>2008</th>
<th>2012</th>
<th>Change since 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population 15 years and above</td>
<td>1,024,110</td>
<td>1,106,854</td>
<td>1,313,662</td>
<td>208,808</td>
</tr>
<tr>
<td>Labour force</td>
<td>493,448</td>
<td>678,680</td>
<td>868,268</td>
<td>189,588</td>
</tr>
<tr>
<td>Employed population</td>
<td>385,329</td>
<td>331,444</td>
<td>630,094</td>
<td>298,650</td>
</tr>
<tr>
<td>Unemployed population – broad</td>
<td>223,281</td>
<td>347,237</td>
<td>238,174</td>
<td>-109,063</td>
</tr>
<tr>
<td>Not economically active population</td>
<td>530,662</td>
<td>428,174</td>
<td>404,122</td>
<td>-24,052</td>
</tr>
<tr>
<td>Rates (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployment rate – broad</td>
<td>36.7</td>
<td>51.2</td>
<td>27.4</td>
<td>-23.9</td>
</tr>
<tr>
<td>Labour force participation rate</td>
<td>47.9</td>
<td>55.4</td>
<td>66.0</td>
<td>10.6</td>
</tr>
</tbody>
</table>


One of the reasons for the dramatic drop in the 2012 unemployment figures is due to the Namibia Statistics Agency using new international
best practices in a revised method of sampling and surveying in the gathering of unemployment data.

**Unemployment by educational level**

Just as poverty declines with education so also does unemployment. The 2012 Namibia labour force survey shows that people with post school training (university, teacher’s training or post-graduate) face the least risk of being unemployed with only 4.7% being unemployed. People with a junior primary education had an unemployment rate of 33% and those with secondary schooling 30%.

**Table 3: Unemployed population by highest level of education attained**

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th></th>
<th>Male</th>
<th></th>
<th>Both sexes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Labour force</td>
<td>Unemployed (broad)</td>
<td>%</td>
<td>Labour force</td>
<td>Unemployed (broad)</td>
<td>%</td>
</tr>
<tr>
<td>None</td>
<td>42,086</td>
<td>11,467</td>
<td>27.2</td>
<td>51,260</td>
<td>9,028</td>
<td>17.6</td>
</tr>
<tr>
<td>Primary education</td>
<td>95,217</td>
<td>31,062</td>
<td>32.6</td>
<td>99,338</td>
<td>26,787</td>
<td>27.0</td>
</tr>
<tr>
<td>Junior Secondary</td>
<td>188,145</td>
<td>64,347</td>
<td>34.3</td>
<td>134,876</td>
<td>36,996</td>
<td>27.4</td>
</tr>
<tr>
<td>Senior Secondary</td>
<td>98,500</td>
<td>30,507</td>
<td>31.0</td>
<td>99,291</td>
<td>21,374</td>
<td>21.5</td>
</tr>
<tr>
<td>Certificate and Diploma</td>
<td>1,706</td>
<td>178</td>
<td>10.4</td>
<td>3,499</td>
<td>271</td>
<td>7.7</td>
</tr>
<tr>
<td>Post-school</td>
<td>28,747</td>
<td>1,317</td>
<td>4.6</td>
<td>29,201</td>
<td>1,424</td>
<td>4.9</td>
</tr>
<tr>
<td>Don’t know</td>
<td>6,157</td>
<td>1,294</td>
<td>21.0</td>
<td>10,524</td>
<td>2,123</td>
<td>20.7</td>
</tr>
<tr>
<td>Total</td>
<td>440,562</td>
<td>140,172</td>
<td>31.8</td>
<td>427,708</td>
<td>98,002</td>
<td>22.9</td>
</tr>
</tbody>
</table>


However, people with no education (i.e. no formal education) faced a lower risk of unemployment than those having an education below post school training. The Namibia Statistics Agency suggests in its report that “This can most likely be explained with the older generation that did not benefit from access to education but make a living from mainly subsistence farming” (Namibia Statistics Agency, 2013, p. 15).
Employment by educational level

Looking at the distribution of the already employed population in 2012 we see that 11.6% have no formal schooling, 21.7% have primary schooling, 32% have junior secondary and 23.2% have senior secondary schooling, while about 9.5% have some form of post-secondary schooling.

Table 4: Employment by educational level

<table>
<thead>
<tr>
<th>Educational level</th>
<th>Female</th>
<th>%</th>
<th>Male</th>
<th>%</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No formal education</td>
<td>30,622</td>
<td>10.2</td>
<td>42,232</td>
<td>12.8</td>
<td>72,854</td>
<td>11.6</td>
</tr>
<tr>
<td>Primary education</td>
<td>64,155</td>
<td>21.4</td>
<td>72,551</td>
<td>22.0</td>
<td>136,707</td>
<td>21.7</td>
</tr>
<tr>
<td>Junior Secondary</td>
<td>103,798</td>
<td>34</td>
<td>97,880</td>
<td>29.7</td>
<td>201,678</td>
<td>32.0</td>
</tr>
<tr>
<td>Senior Secondary</td>
<td>67,993</td>
<td>22.6</td>
<td>77,907</td>
<td>23.6</td>
<td>145,900</td>
<td>23.2</td>
</tr>
<tr>
<td>Certificate and Diploma</td>
<td>1,528</td>
<td>0.5</td>
<td>3,228</td>
<td>1.0</td>
<td>4,756</td>
<td>0.8</td>
</tr>
<tr>
<td>University</td>
<td>17,370</td>
<td>5.8</td>
<td>16,700</td>
<td>5.1</td>
<td>43,070</td>
<td>5.4</td>
</tr>
<tr>
<td>Postgraduate</td>
<td>2,637</td>
<td>0.9</td>
<td>5,742</td>
<td>1.7</td>
<td>8,380</td>
<td>1.3</td>
</tr>
<tr>
<td>Teacher’s training</td>
<td>7,423</td>
<td>2.5</td>
<td>5,335</td>
<td>1.6</td>
<td>12,758</td>
<td>2.0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>4,863</td>
<td>1.6</td>
<td>8,129</td>
<td>2.5</td>
<td>12,992</td>
<td>2.1</td>
</tr>
<tr>
<td>Total</td>
<td>300,390</td>
<td>100.0</td>
<td>329,704</td>
<td>100.0</td>
<td>630,094</td>
<td>100.0</td>
</tr>
</tbody>
</table>


Thus those with junior secondary schooling form the largest group in the current employed labour force, comprising 29.7% males and 34.6% females. “Overall, the table shows that employed females tend to have higher education than employed males” (Namibia Statistics Agency, 2013, p. 10).

Assessing the performance of our schools

Assessing educational performance of a system is typically contentious and hotly debated. It usually evokes competing claims as to causes of success or shortfalls and suggestions for solutions. This can be very
frustrating for parents and learners who simply wish for quality education in order to realize their personal social and economic goals.

It is important to recognize that much has been achieved in education in Namibia since independence. Physical access to education at all levels has been opened to many previously excluded by the racial and segregationists policies of the colonial era. But it will come as no surprise to most Namibian educators that the education system is not producing student performance outcomes that are even close to the expectations and especially the needs of the nation.

One of a number of measures of educational performance in Namibia is the periodic international Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ) surveys administered across most of the Southern African countries. SACMEQ tests Grade 6 students in language and mathematics and also surveys a range of school, teacher and classroom factors. Thus for example in Namibia SACMEQ III in 2007 tested 6398 Grade 6 students, and 827 teachers, in 267 schools.

Table 5: Proportion of Grade 6 children functionally literate and numerate in 2000 and 2007 by country

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Botswana</td>
<td>91.6</td>
<td>89.4</td>
<td>75.4</td>
<td>77.5</td>
</tr>
<tr>
<td>Kenya</td>
<td>95.4</td>
<td>92.0</td>
<td>91.4</td>
<td>88.8</td>
</tr>
<tr>
<td>Lesotho</td>
<td>75.7</td>
<td>78.8</td>
<td>41.1</td>
<td>58.2</td>
</tr>
<tr>
<td>Malawi</td>
<td>61.5</td>
<td>63.4</td>
<td>33.9</td>
<td>40.2</td>
</tr>
<tr>
<td>Mauritius</td>
<td>83.4</td>
<td>88.9</td>
<td>83.2</td>
<td>88.8</td>
</tr>
<tr>
<td>Mozambique</td>
<td>94.6</td>
<td>78.5</td>
<td>90.3</td>
<td>67.5</td>
</tr>
<tr>
<td>Namibia</td>
<td>62.6</td>
<td>86.4</td>
<td>29.1</td>
<td>52.3</td>
</tr>
<tr>
<td>Seychelles</td>
<td>91.4</td>
<td>88.3</td>
<td>80.6</td>
<td>82.2</td>
</tr>
<tr>
<td>South Africa</td>
<td>72.8</td>
<td>72.7</td>
<td>53.6</td>
<td>59.9</td>
</tr>
<tr>
<td>Swaziland</td>
<td>98.7</td>
<td>98.5</td>
<td>83.4</td>
<td>91.4</td>
</tr>
<tr>
<td>Tanzania</td>
<td>92.7</td>
<td>96.5</td>
<td>79.3</td>
<td>86.8</td>
</tr>
<tr>
<td>Uganda</td>
<td>78.1</td>
<td>79.6</td>
<td>66.4</td>
<td>61.3</td>
</tr>
<tr>
<td>Zambia</td>
<td>56.1</td>
<td>55.9</td>
<td>36.5</td>
<td>33.0</td>
</tr>
<tr>
<td>Zanzibar</td>
<td>82.7</td>
<td>90.8</td>
<td>64.5</td>
<td>66.6</td>
</tr>
</tbody>
</table>

Comparing Namibia’s levels of functional literacy and functional numeracy with the other participating Southern African countries (Table 5) in the SACMEQ surveys, Namibia stands out from the others in the dramatic improvement seen in functional literacy between 2000 and 2007 from a rate of 62.6% rising to 86.4% but also in the big improvement in functional numeracy from a level of only 29.1% being functionally numerate in 2000 rising to some 52.3% being functionally numerate in 2007.

Possible reasons for the dramatic improvement in the Namibian functionally literate results of the Grade 6 age cohort between 2000 and 2007 were suggested to the author (personal interview) by Joy Mbangu, an experienced school inspector from the north (2013), as possibly the introduction of the Standardized Achievement Test in Grade 5 and Grade 7 across Namibia in that period and also a greater use of professional development programs.

But any celebration of the achievement in functional numeracy needs to be tempered by noting that this still means that almost half the cohort is still functionally innumerate and also Namibia scores at the lower end on this measure when compared to many of its neighbours. This is a source of real concern.

Table 6: Namibia at a glance – SACMEQ II & III – Proportion of grade 6 age cohort functionally illiterate and innumerate.

<table>
<thead>
<tr>
<th>SACMEQ III Sub-groups</th>
<th>School location</th>
<th>Gender</th>
<th>Student wealth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>13.6</td>
<td>13.6</td>
<td>13.9</td>
</tr>
<tr>
<td>Student reading score</td>
<td>513</td>
<td>497</td>
<td>449</td>
</tr>
<tr>
<td>Mathematics score</td>
<td>512</td>
<td>471</td>
<td>431</td>
</tr>
<tr>
<td>Functionally illiterate</td>
<td>18</td>
<td>14</td>
<td>43</td>
</tr>
<tr>
<td>Functionally innumerate</td>
<td>30</td>
<td>48</td>
<td>77</td>
</tr>
</tbody>
</table>

Thus the 2007 SACMEQ III survey (Table 6) shows a continued deficiency in Grade 6 Namibian children’s basic literacy and numeracy. It showed that while only 14% of the Grade 6 age-specific population were functionally *illiterate*, a shocking 48% or almost half of all the Namibian age-specific students in Grade 6, were functionally *innumerate*.  

The improvements are of course to be celebrated but the continuing low level of functional numeracy, of almost half the age cohort, is a major concern for educators and all concerned with creating a skilled labour force for a modern economy.

### Inequality

Inequality of wealth and income is still very high in Namibia. Addressing inequality is seen as a major goal of the Namibian government as demonstrated by the fact that it is one of the three overarching goals of the 4th National Development Plan. The three overarching goals of the 4th NDP are: 1) High and sustained economic growth; 2) Employment creation; and 3) Increased income equality (National Planning Commission, 2012, p. x).

An important 2012 study of poverty and inequality in Namibia by the Namibia Statistics Agency (Namibia Statistics Agency, 2012, p. 32) explains that “Unlike poverty analysis, which focuses only on the section of the population that is poor, inequality analysis considers the entire population. Inequality is defined as disparities in the distribution of economic assets (wealth) and income within or between populations or individuals”. The Gini Coefficient is often used to show the extent of inequality in the distribution of income and wellbeing. The Gini Coefficient has a value of zero for perfect equality and 1 for perfect inequality.

---

1. In the area of methodology, Taylor from the University of Pretoria and Spaull from the University of Stellenbosch (2013) argue that by using age-specific enrolment data from the household Demographic and Health Surveys, rather than official school enrolment records, one gets a more accurate picture of primary school performance in these countries and it would better reflect the “proportion of children in an age-specific population that reach particular levels of literacy and numeracy” (Taylor & Spaull, 2013, p. 1).
The National Statistics Agency reveals that inequality in Namibia has declined between 1993/1994 and 2003/2004, but is still high by international standards. The Gini Coefficient for inequality is currently estimated at 0.597, a reduction from 0.646 in 1993/1994. “Although inequality is showing a declining trend over the last seventeen years, the rate of decline is slowing.” (Namibia Statistics Agency, 2012,p.?) Of interest too is that in some regions inequality is increasing while in others it is decreasing.

A recent debate begun in the US, in part encouraged by some recent major studies and President Obama’s 2014 State of the Union address, has shifted the inequality debate to also asking if there is any or sufficient social mobility between classes, viz. have or can people move up the economic ladder in society and how easily? The evidence from the US shows that for some people in some areas there is no social mobility between classes even over a number of generations (The Economist, Feb 1st 2014). A study of social mobility in Namibia would add immeasurably to the debate on opportunity and social and economic development in Namibia.

Upper-middle income status


This reclassification has had some positive but also negative consequences. Rose Orlik, a commentator for The Guardian newspaper (Orlik, 2009), argued that while Namibia can be proud of this new status and it could encourage foreign investment it may have lost more than it has gained, such as preferential trade status that their less successful peer countries still enjoy.

The economy

Namibia was placed as 139th out of 229 countries ranked in size of the economy with a GDP of US$17.790 billion (purchasing power parity) in 2013 (CIA, The World Factbook, 2014).

Mining, tourism, livestock rearing, fishing, metallurgy, and food processing have been mainstays of the Namibian economy, with construction growing rapidly in recent years. Namibia’s economy is closely linked to South Africa’s economy through trade, investment, and
common monetary policies. In addition, Namibia’s receipts from the Southern African Customs Union (SACU) revenue pool make up almost 40% of government revenue.

**Figure 4: Namibia – Composition of exports in 2011 (% of total merchandise exports)**

![Pie chart showing export composition]

Metals and minerals provide the majority of export revenue, followed by fish, tourism, livestock, logistics services, one of Africa’s best beers, beef, and grapes.

**Economic sectors**

The services sector, which includes government and tourism, accounts for 63% of total GDP, manufacturing 12%, agriculture 8% and mining contributes 8% and construction 4% to GDP (2012 estimates).
Mining accounts for only 8% of GDP, but provides more than 50% of foreign exchange earnings. Rich alluvial diamond deposits make Namibia a primary source for gem-quality diamonds. Namibia is the world’s fourth-largest producer of uranium. It also produces large quantities of zinc and is a small producer of gold and other minerals. In 2012 the mining sector employed only about 1.8% of employed persons 15 years and older.

The tourism industry in Namibia which contributed about 16% of GDP, is world-class and successful. In 2010 there were some 1.2 million annual foreign arrivals. Of these 984,099 were tourists coming from Europe, North and South America, Africa and the Far-East (Venture Publications, 2013, p. 13). The almost universal response is to fall in love with Namibia and its landscape, the vast and sparsely populated open and safe country, and the amazing places to visit. These include the unique Etosha Pan National Park teeming with elephants, zebra and herds of antelope, a coastal plain with its attractive deserts, Sossusvlei’s giant red sand dunes, the Great Fish River Canyon in the south that rivals the Grand Canyon, Spitzkop for climbing enthusiasts, the Brandberg, and Twyfelfontein’s huge collection of San rock etchings. There are both private and public game reserves, and a highly sophisticated efficient tourist service industry and infrastructure, with excellent roads, good camping, first rate hotels and game lodges, sea fishing, hunting, self-arranged and guided tours.

Agriculture is the largest form of employment in Namibia, employing some 27.4% of employed persons over 15 but contributes only 8% of the GDP. Only 2% of Namibia’s land receives sufficient rainfall to grow crops. Irrigation is only possible in the valleys of the Orange, Kunene and Okavango rivers but animal grazing covers a much wider area of the country. Cattle raising is predominant in the central and northern regions, and karakul sheep and goat farming are found in the more arid southern regions. Subsistence farming is mainly confined to the ‘communal lands’ of the north, where roaming cattle herds are prevalent and the main crops are millet, sorghum, corn, and peanuts. Grapes, grown mostly along the Orange River in the country’s arid south, are an increasingly important commercial crop (Wikipedia, 2014). The beef export industry in Namibia is very sophisticated and becoming even more so. It is notable for its willingness and capacity to comply with the strict EU health control requirements and thus has a respected and extensive system of management and control of all livestock of individual animals intended for export, from original farm to quarantine farms to abattoirs, which EU appointed health staff audit at all
stages of the system. It is currently also engaged in refining its strategies to provide specialised meat cuts to selected markets, control costs and also to diversify beyond the EU market (Agritrade, 2013).

While **manufacturing** contributed about 12% of GDP it is seen by policy makers as performing below its long-term potential. It is inhibited by a small domestic market and widely dispersed population and a small skilled labour force. The **logistics industry** is gaining increasing attention in Namibia. Walvis Bay is a well-developed, deep-water port, and Namibia's fishing infrastructure is heavily concentrated there. The Namibian Government expects Walvis Bay to become an important commercial gateway to the Southern African region. Namibia also boasts world-class civil aviation facilities and an extensive, well-maintained land transportation network. Construction is underway on two new arteries – the Trans-Caprivi/Zambezi Highway and Trans-Kalahari Highway – which will open up the region's access to Walvis Bay. The national strategy for developing Namibia’s logistics services so that it can become a regional centre of such services is a realistic prospect given its location and existing skills in this area.

**The construction** sector contributes some 4% to GDP. The consensus appears to be that construction will accelerate over the near term and will maintain a high growth rate over the near term as a result of the government's major investment drives. Thus the Business Monitor International infrastructure report is forecasting 17.1% and 16.3% real construction industry value growth in 2013 and 2014 respectively. They argue that the construction boom will be driven predominantly by short-term government stimulus, such as the Targeted Intervention Programme for Employment and Economic Growth (TIPEEG). The potential to sustain the building boom into the latter part of the 10-year forecast will depend on unlocking the energy sector potential and attracting significant volumes of private capital to make big-ticket investments possible. In February 2014 the Namibian power utility NamPower announced it had reached agreement with Zambia’s Copperbelt Energy Corporation (CEC) to develop the long anticipated gas-to-power Kudu power plant at Uubvlei near Oranjemund. The N$12.6 billion, 800—megawatt plant will be using gas from the adjacent off-shore Kudu gas field and is scheduled for commissioning in late 2017 or early 2018. (Business Day, Feb 11 2014; Business Monitor International, 2014; Bank of Namibia, 2012).
Economic performance

Namibia is recognized for its good infrastructure, and also for its rich natural resources, sound economic management, good governance, basic civic freedoms and economic potential, but it is still based on a narrow economic base and has some key economic and social challenges that need to be tackled. This seems to sum up the assessment of Namibia’s economic environment and performance by some respected independent institutions and also the Namibian Government itself.

With independence Namibia inherited a well-functioning physical infrastructure, a market economy, rich natural resources, and a relatively strong public administration. KPMG Namibia, international audit and tax consultants, recently observed that:

Namibia is blessed with good infrastructure as well as political stability, however, despite its potential the economy remains poorly diversified and restricted by a narrow economic base. … The biggest challenge for Namibia’s economy is to diversify away from mining activities as the sector employs many (skilled) foreign workers and only 3% of the local population. … About two-thirds of the Namibian population is somehow dependent on agriculture for their livelihoods. Manufacturing activity is also not very diverse, given the strong competition from South Africa, and is focussed on the food, beverage and fishing industries.

(KPMG, 2013)

The World Bank in a recent review of Namibia’s economy is also very complimentary and gives Namibia a high rating for its good economic management and economic and social achievements since gaining independence. It states; “Namibia has enjoyed considerable successes since it gained independence from South Africa in 1990 resulting from sound economic management, good governance, basic civic freedoms, and respect for human rights” (World Bank, October 2013).

The World Bank’s review goes on to offer details of this progress and the achievements:

Namibia has made significant progress in addressing many development challenges. Access to basic education, primary health care services, and safe water is high and growing. Sound public policies are helping to lay the foundation for gender equality. Since independence, Namibia has been a leader in the area of natural resource conservation, with 43% of total land under conservation
in 2012, up from 15% in 1990, and the country’s entire 1,570 km coastline enjoying protected status. Namibia maintains social safety net programs for the elderly, disabled, orphans, vulnerable children, and war veterans, and has enacted a Social Security Act that provides for maternity leave, sick leave, and medical benefits to Namibians.

(World Bank, October 2013)

The development challenges

Despite the many and notable political, social and economic achievements, there remain some important development challenges for both the Government and every Namibian. Both the World Bank and the Namibian Government at the highest level are frank in their conclusion that economic performance in some vital areas falls short of what is needed to address some of the key national economic and social goals and challenges.

As the Director General of the National Planning Commission in the introduction to Namibia’s 4th National Development Plan 2012/13 – 2016/17 states, it inherited four challenges to be addressed:

At independence in 1990, Namibia inherited a dual economy with the four interrelated challenges of low economic growth, a high rate of poverty, inequitable distribution of wealth and income, and high unemployment. Since the early 1990s, the new, democratically elected Government has been addressing these challenges.

(National Planning Commission, 2012, p. ix)

The 4th National Development Plan review of past performance, while recognizing a range of important economic, institutional and social achievements, goes on to identify unsatisfactory economic performance in vital areas.

A review of our economic and social performance shows a mixed picture. We have been successful in critical institutional areas necessary for sustained economic growth. Namibia boasts strong institutions, including good governance, the rule of law, and the protection of property rights – to name but a few of its most positive achievements. We can also be proud of a stable macroeconomic environment anchored in sustainable fiscal and debt dynamics, which is the envy of many in the current global environment.
However, our growth trajectory – while positive and translating into gains in per capita income – has been below par when compared with more dynamic and rapidly growing emerging market economies, especially in Asia. Our success rate in creating decent jobs for most of our citizens has also not been satisfactory. According to the latest official employment statistics, slightly more than half of our people that are available for work simply cannot find a job.

(National Planning Commission, 2012, p. xii)

The 4th NDP in its review also highlights the unhealthy shallowness of the economic structure with its over-dependence on a resource base and on primary commodities, often exported with little value added and also the poor performance in job creation; both points also made by the World Bank in its review:

Similarly, while recording positive growth, our economic structure remains rather shallow and resource-based. As before Independence in 1990, we are by and large still known as a nation of minerals, fish and beef. Despite some progress in areas such as tourism, we have not made a clear break from being on the map because of our primary commodities to a nation making its mark by way of services and manufacturing, and this partly explains the paltry performance with respect to job creation. It also underscores why outcomes with respect to poverty reduction and income distribution have been less than desired.

(National Planning Commission, 2012, p. xii)

Responding to the Namibian development challenges

Before looking at the main features of the 4th National Development Plan, it is important to acknowledge that Namibians are responding to the development challenges in many ways. Each individual resident contributes by his or her daily activities: be it in formal employment or informal economic activity. Even the unemployed are making contributions in the home and in the community. There are also the countless contributions to economic and social development from thousands of small and large businesses both local and foreign, from community organizations, NGOs, and from government departments through the numerous services offered from education, health, policing and security, the system of justice and in planning, governance and legislation. The individual and collective efforts of Namibians should not only be acknowledged and celebrated but it is the source of the real power
of the nation to continue to make progress in achieving its development
goals and to continue to improve in its economic and social well-being.

Namibia’s 4th National Development Plan is an important response to
the development challenges previously identified. As the President of
Namibia, Hifikepunye Pohamba, points out, a conscious decision was
taken “to focus our energy and resources on areas with the greatest
potential to impact our development challenges”. (National Planning
Commission, 2012, p. vii). For this reason NDP4 concentrates on fewer
goals and has selected three overarching goals: 1) High and sustained
economic growth; 2) Employment creation; 3) Increased income equality.

Figure 5: Namibia’s 4th National Development Plan (NDP4) – Plan &
Vision 2030

It identifies what it calls basic enablers that are necessary conditions for
economic development, and these include: 1) to create an enabling
institutional environment; 2) to improve education and skills management;
3) establish a quality health system; 4) assist in reducing extreme poverty;
and 5) upgrade the public infrastructure, needed for the industries to perform at the required level of output, arguing that “it is assumed that, without them, economic development will be difficult – if not impossible” (National Planning Commission, 2012, p. xi).

It then adopts a target approach to industrial development and proposes that the country focus on the following priority economic sectors: 1) logistics and distribution; 2) tourism; 3) enhancing manufacturing capability; and 4) agriculture.

In his foreword to the NDP4 plan, the President Hifikepunye Pohamba says that the full implementation of NDP4 requires a number of things: Firstly: “a mindset that sees opportunities and possibilities rather than obstacles”, even while acknowledging that our challenges are formidable. Secondly: “the full participation of all Namibians: men, women, boys and girls”. Thirdly: “it will be as good as our ability and commitment to implement it”. By way of example arguing that it would be a mistake to want to be industrialized by 2030 but “then not prepare ourselves for making the necessary investment to create those industries. Equally it will make a mockery of our long-term vision to create a knowledge-based society if we do not take bold steps to invest in the necessary research and development” (National Planning Commission, 2012, p. vii).

The vital role of education

Education and its essential role in the success of the social and economic development of Namibia is not surprisingly underlined in Namibia’s 4th National Development Plan as one of the vital or basic enablers. This ought to be a rallying call to all within education to examine what they can and will do to improve and increase the contribution of education to national development.

The NDP4 analysis reports the conclusions of some within the education system that “despite significant investment and numerous efforts to strengthen education and skills, our education system is still perceived as performing below its potential and, therefore, remains a strategic area under NDP4” (National Planning Commission, 2012, p. xiv).

Some of the key education concerns mentioned in the report include: quality of the outcomes at various levels, access to quality early childhood development, vocational training opportunities, and the mismatch between the supply of and demand for skilled labour. The report states that these concerns will be addressed under NDP4 and “consequently, the desired outcome under this challenge is that, by the end of 2017, Namibia should be characterized by a culture of learning supported by an integrated, high-
quality education system that capacitates the population to meet current and future demands for skills.” Ongoing strategies to be pursued and intensified in this regard include –

- Improved teaching standards and curriculum development
- Improved availability of the appropriate textbooks and other learning materials
- Improved school education achievements
- Increased provision of opportunities for vocational education and training (VET), and

Conclusion

This chapter provided an overview of the Namibian socio-economic landscape. In it I argued for an appreciation of the features of that landscape – its natural and other economic resources, population, economy, social indicators, the main socio-economic goals and challenges of the society – by educational researchers, planners, managers and teachers. The value of this is to hopefully get new insights into ways that they get education to do a better job of contributing its vital piece to the economic and social development of Namibians and the realization of their development goals.

The contribution to Namibia’s social and economic development by mathematics teachers and educators is central and vital. The challenge to raise numeracy performance is great. Although the solutions may not be immediately obvious, an important step towards realising these solutions is in-depth classroom-based research.

If there is one thing that the mathematics education community can do that will have significant benefits for the social and economic development of Namibia, it is to raise mathematics performance across all age groups. This collection of mathematics education research studies is part of just such an effort.

REFERENCES


POST-APARTHEID PEDAGOGIC
REFORM IN NAMIBIA: THE ROUTE TO
LEARNER-CENTRED PEDAGOGY AND
ITS IMPLEMENTATION

JOHN NYAMBE AND DI WILMOT

Background
Recent studies in sub-Saharan African countries (Storeng, 2001; O’Sullivan, 2004; Sikoyo, 2006; Wilmot, 2006; Altinyelken, 2010) have revealed widespread interest in the reformation of pedagogical practices. The observed trend in these countries has been a move away from what is generally termed traditional or teacher-centred approaches, towards learner-centred approaches. Traditional teacher-centred approaches have been characterized as rigid, authoritarian and teacher dominated, assigning learners the role of passive recipients and reducing learning to the rote memorization of bits and pieces of information to be given back in an examination. It is argued that traditional teacher-centred teaching does not promote meaningful learning and is to blame for the poor quality of education in these countries (Altinyelken, 2010).

Learner-centred pedagogy, on the other hand, has been characterized as a democratic and highly participatory form of pedagogy that accords the learner a voice in various aspects of teaching and learning, including the selection of learning discourses, their sequencing, pacing and evaluation. It has been claimed in these countries that unlike teacher-centred pedagogy, learner-centred pedagogy promotes critical and reflective thinking and deeper conceptual learning. However, studies show that despite the reforms consequent on the official adoption of learner-centred pedagogy, traditional teacher-centred forms of teaching still prevail in most African classrooms (Storeng, 2001; Nyambe, 2008; Altinyelken, 2010; Nyambe & Wilmot, 2012).
It has also been observed in several studies (Tabulwa, 2003) that, its appealing features aside (such as its democratic and constructivist orientations), learner-centred pedagogy has been introduced in most African countries as an agenda imposed or prescribed by international donor agencies. It has been argued that learner-centred pedagogy has a “hidden agenda” of being a “political artefact” or “ideology” that facilitates the westernization and capitalist penetration of developing countries under the guise of democratization (Tabulwa, 2003, p. 10). In these countries, the pedagogy has been presented as “a one-size-fits-all pedagogic approach, a universal pedagogy – one that works with equal effectiveness irrespective of context” (Storeng, 2001, p. 34; Tabulwa, 2003, p. 9). Yet, despite the purported role it plays in enhancing learning outcomes, it is argued that “to date, there is no study that has conclusively established that learner-centredness is necessarily superior to traditional teaching in third-world countries in terms of improving student’s achievements in test scores” (Tabulwa, 2003, p. 10). In fact, there is an emerging trend towards favouring mixed pedagogies as potentially the most effective way of enhancing learning outcomes (Nyambe & Wilmot, 2012).

Namibia has been no exception to the pedagogic reform that has been sweeping through the continent. This chapter focuses on the pedagogic reforms in Namibia, outlining why learner-centred pedagogy was adopted by the reform process, where it came from, who conceptualized it and implemented it, and what challenges were associated therewith.

The rationale for pedagogic reform

At independence from South Africa in 1990, Namibian classrooms were effectively a microcosm of the segregated and oppressive apartheid society that privileged an elitist white minority population at the expense of the black majorities. Classrooms were guided by an authoritarian teacher-centred pedagogy – a pedagogy deliberately designed to normalize, naturalize and legitimate apartheid Bantu education. Not only was this form of pedagogy apparently ineffectual in improving the quality of education, it also seemed to stand in stark contrast to the newly adopted political and ideological values of democracy and social justice that were to guide the new Namibia. The political project at independence sought the transformation, democratization, and liberation of a nation that had suffered more than a hundred years of colonial oppression.
Transformation at the broader macro-level of society demanded an accompanying transformation at the micro-level of social processes, processes such as pedagogic practice. Thus with its democratic and emancipatory features, learner-centred pedagogy was highly appealing to education policy makers. Pedagogic reform in post-apartheid Namibia, in particular the adoption of learner-centred pedagogy, was an inextricable part of the post-independence political project of liberating and democratizing socio-economic structures in society, industry and government. Within the education sector, the need to reform pedagogy, and the subsequent official adoption of learner-centred pedagogy, were located within the ‘rights’-based and social justice context of education for all, underpinned by the goals of access, equity, quality and democracy:

As we make the transition from educating an elite to education for all we are also making another shift, from teacher-centred to learner-centred education [emphasis mine] … we are accustomed to classrooms where attention and activities are focused on the teacher. Indeed, we have probably all encountered teachers so set in their ways that they pay little attention to the backgrounds, interests, and orientations of their students. They continue as they have in the past regardless of who is in their class. Teacher centred instruction is inefficient and frustrating to most learners, and certainly is not consistent with education for all.

(Ministry of Education and Culture [MEC], 1993, p. 10)

Aside from the political project of transformation following the attainment of independence, the roots of learner-centred pedagogy in post-apartheid Namibia can be traced to the pedagogic activities of SWAPO’s (South West Africa People’s Organization) Department of Education in exile, which experimented with alternative pedagogies in several of its education establishments (Lewis & Angula, 1997; Dahlstrom, 1999). There is evidence that these educational activities in exile constituted “the starting point for undoing apartheid in education and training” in post-apartheid Namibia and provided a model on which future educational reforms would be based (Cohen, 1994; Angula, 1999; Swarts, 1999). However, as indicated above, efforts to experiment with or to adopt and implement learner-centred pedagogy, either in exile or in independent Namibia, was never without the backing – at times, the prescription – of international donor agencies and their professional staff.
Conceptualizing and explicating the new pedagogy

In the preceding discussion it was mentioned that learner-centred pedagogy is a “world model of teaching” (Storeng, 2001) that has been adopted globally. While the pedagogy is well established in western countries, its uptake in African countries is recent. After many years of apartheid education that entrenched traditional forms of teaching, the adoption of learner-centred pedagogy in post-apartheid Namibia demanded proper conceptualization and explication in order to achieve meaningful uptake among educators. The conceptualization and explication exercise was a complex one, involving several pedagogic agents, agencies and players from both the local and the international communities.

The 1991 Etosha Conference was a key platform that brought together various players to create a common framework for the new pedagogy by sharing experiences, understanding and practices. Augmenting the Etosha Conference, specific agencies, both state and non-state, carried forward the task of explicating the new pedagogy in order to leverage for its implementation at school level. The National Institute for Educational Development (NIED), supported by several donor agencies and their professional staff, was the most prominent state agency charged with the responsibility to develop, conceptualize and simplify learner-centred pedagogy in a manner that would enable its meaningful uptake and proper implementation in schools. Serving as the professional arm of the Ministry of Education responsible for spearheading the post-apartheid reform process, NIED sought to embed the principles and practices of learner-centred pedagogy in its curriculum documents and provide epistemological empowerment to educators through professional development in the new pedagogy.

A unique feature in the operations of NIED as it embarked upon the conceptualization of the new pedagogy was the overwhelming number of donor-funded projects that surrounded the Institute. It was the self-proclaimed aim of these donor-funded projects to provide intellectual and professional mentorship to NIED in order to ensure that the new pedagogy was properly interpreted and implemented. A celebratory monument inscribed with more than thirty names of donor projects involved in this exercise has been erected in the central square of NIED.
Challenges faced in the implementation of learner-centred pedagogy

Despite its adoption as the official pedagogy, the implementation of learner-centred pedagogy in post-apartheid Namibia has never been without challenges. These have ranged from outright resistance to the reform, to a lack of staff preparedness to take on the new pedagogy, and the nature of the material context in which it had to be implemented. These challenges are elaborated upon in the following sections.

Resistance to learner-centred pedagogy

Learner-centred pedagogy has been implemented in post-apartheid Namibia over a rocky pedagogic terrain involving tensions, conflicts, resistance and criticism (Nyambe, 2008). This terrain has over the years exhibited misgivings, discontent and reservations regarding the new pedagogy, with oppositional forces advancing epistemological, ideological, and, at times, ‘common sense’ arguments against the new pedagogy. The resistance to and criticism of the pedagogy have included, among others, allegations of watering down academic standards, teaching little subject content owing to the constructivist methodology, chaotic and unruly classrooms due to democratic underpinnings, learner indiscipline, and little learning going on due to the use of group work.

One particular programme, the Basic Education Teachers Diploma (BETD) programme, which was designed to champion learner-centred pedagogy in all its aspects, has been at the centre of the criticism of learner-centred pedagogy. Due to its theoretical orientations (constructivism, democracy, etc.), the BETD programme evoked widespread dislike among members of the ordinary public, teachers employed by the state, and students (Government of the Republic of Namibia [GRN], 1999). Even more important was the fact that there were some teacher educators, who despite their very crucial role in preparing teachers to teach in a learner-centred manner, were equally averse to the new pedagogy. As putative implementers, teachers and teacher educators who were opposed to the new pedagogy were potentially a dangerous force as they could sabotage the reform through their reservations about the pedagogy. The fact that teacher educators were tasked with implementing what they did not believe in meant that they could not be enthusiastic about the reform.
Overt resistance towards the epistemological and ideological tenets of learner-centred pedagogy underpinning the BETD programme also came from the University of Namibia, as seen in its decision to deny credit transfer to BETD graduates (UNAM, 1998). The basic tenets of the BETD, involving social constructivism, learner-centredness, and critical and transformative pedagogy, were seen by the University as distracting from serious academic learning. The programme was consequently criticized for teaching ‘less academic content’ – that is, for teaching less subject content and placing too much emphasis on the acquisition of skills (Nyambe, 2001). It was these factors that led to the programme’s prematurely being phased out in 2010 in favour of positivist-oriented academic content teaching.

The ruggedness of the pedagogical terrain was aggravated by the policy of National Reconciliation that dictated the socio-political context within which the post-independence reform initiatives were implemented. Not only did this Policy provide for the retention of conservative government bureaucrats from the former apartheid regime, it also meant that reform initiatives could only be delivered in an atmosphere characterized by compromise, gradualism, and negotiation, rather than political radicalism.

**Persistent traditional pedagogic frame factors inhibiting uptake of the new pedagogy**

Another challenge in the implementation of learner-centred pedagogy has been what Nyambe and Wilmot (2012) term the official “double-speak” or “fork-tongued” discourse. This transmits to the classroom two contradictory messages: on the one hand, teachers are being exhorted to change their classroom practice from teacher-centredness to learner-centredness, while on the other hand, officials continue to cling to traditional pedagogic structures and arrangements that are antithetical to the new pedagogy. The call for change to learner-centred pedagogy has not gone much beyond official rhetoric. How can teachers’ pedagogic skills be changed from teacher-centredness to learner-centredness while fundamental pedagogic frame factors such as the external controls imposed on the pedagogic process (e.g. controls over the selection of discourses, scheduling, etc.) remain unchanged? This approach to pedagogic reform reflects a narrow reductionist understanding that reduces learner-centred pedagogy to a technical rationality concerned only with simple tricks of the trade while ignoring changes in the broader
structural sphere – structural changes that condition or frame teachers’ interpretation and practice of learner-centred pedagogy.

It is argued, therefore, that the fork-tongued discourse, anchored in a technicist approach, constitutes one of the key factors that have constrained and stifled the meaningful uptake of the new pedagogy. In order for meaningful transformation of pedagogy to take place, there is a need for a broader perspective that will take into account not only changes in teachers’ pedagogic skills but also changes in broader structural arrangements such as the time-tabling, sequencing and pacing of learning, and challenges to authoritarian views on syllabus coverage.

Learner-centred pedagogy calls for new principles in the organization of time and space, and different rules for the organization of the work of the teacher (Nyambe, 2009). This form of pedagogy is supposed to be democratic, highly participatory and flexible so as to respond to the individual needs and interests of the learner. It implies a pedagogic context where the learner is repositioned to the centre of the classroom and plays an active role in learning. However, within a pedagogic context that is strongly framed externally by traditional factors such as those mentioned above, the chances are high that teachers will resort to traditional ways of teaching, transmitting externally prescribed content and involving learners in the teaching and learning process in only a limited way.

Low professional self-esteem to implement the new pedagogy

In addition to these pedagogic frame factors, self-demeaning and self-deprecatory feelings among some teachers regarding their professional ability meaningfully to interpret and implement the new pedagogy have constituted another challenge. For instance, in a study of teacher educators’ uptake of learner-centred pedagogy, Nyambe (1998) found among teacher educators a preponderance of feelings of self-doubt and a lack of self-confidence in their own professional competencies, not only in terms of participating at the macro-level in the broader activities of the reform process, such as curriculum development and syllabus writing, but even with regard to implementation of learner-centred pedagogy in their own classrooms. Most teacher educators in the study claimed not to have been properly trained, and to have had little exposure, little experience and insufficient knowledge to enable them to properly implement the new pedagogy (Nyambe, 1998, p. 204).
This low professional self-confidence can be attributed at least in part to the fact that most teacher educators were either trained or schooled in the old dispensation, when traditional modes of pedagogy prevailed. But there also appeared to have been few opportunities for epistemological empowerment through professional development that might have enabled teachers and teacher educators to meaningfully interpret and practice learner-centred pedagogy. It was for instance felt that NIED was not providing sufficient opportunities for teacher educators to learn about the new pedagogy and how to implement it. Evidence in the study also suggested that the low professional self-esteem could be linked to a culture that might have been created by the heavy presence of international donor project staff members at the inception of the reform who, despite their official positions as volunteers, were generally seen by their Namibian counterparts as ‘experts’. Most teacher educators in the study yearned for ‘experts’, ‘specialists’ who would “guide”, “direct” and “monitor” the reform process (Nyambe, 2008, p. 214). Absent among teacher educators were any views of themselves as experts in their own right. Instead, they wanted someone to come and provide them with ‘model lessons’, practical examples of how the pedagogy is being implemented in the expert’s country of origin. The ‘expert’ was generally defined as:

An outsider, someone from another country, probably having a doctorate and even white for that matter … an insider such as a fellow teacher educator would not be seen as an expert as people believe an outsider. Teacher educators would prefer experts who are very explicit and specific in terms of guiding and correcting inputs on syllabus or curriculum development.

(Nyambe, 2008, p. 215)

Low professional self-esteem has been a significant factor, inhibiting both the learning of and the proper uptake of the new pedagogy. With low professional self-esteem, teachers and teacher educators were at risk of uncritically accepting the knowledge claims that were being advanced by the so-called experts guiding the reform process and implementation of learner-centred pedagogy as transcendent truths. Thus teachers’ and teacher educators’ own psycho-social contexts of self-doubt and dependence on ‘experts’ have featured among the challenges in the implementation of the new pedagogy in post-apartheid Namibia.
Limited instructional resources to support the new pedagogy

While the successful implementation of learner-centred pedagogy demands the presence of instructional resources to support student learning and exposure to various perspectives and sources of knowledge, the limited availability of such resources in Namibian schools has been one of the contextual factors impeding proper implementation of the new pedagogy. Storeng (2001) associates this particular challenge with the problems of trying to implement a pedagogy transferred from a Western socio-cultural context characterized by material abundance to a remote rural setting characterized by material scarcity. Similar studies in other sub-Saharan countries such as Uganda have also pointed to the lack of instructional resources and facilities needed to support the uptake of the new pedagogy as one of the obstacles (Sikoyo, 2006). The lack of instructional resources and facilities range from the absence of physical facilities such as libraries and, in some cases, even school buildings, to a shortage of textbooks for use in the classroom. This is the case despite the fact that one of the requirements for a learner-centred pedagogy is the availability of sufficient and relevant materials that learners can use as they actively engage in learning activities.

Compounding the lack of instructional resources has been the huge size of classes in some parts of the country. Learner-centred pedagogy is effectively implemented in smaller classes where the teacher can provide individual attention to ensure that each learner is benefiting from the teaching and learning process. In situations where learner numbers are in the range of forty, it becomes extremely difficult to ensure that teaching is adapted to the individual learning needs and interests of each learner.

Clash of cultures

Also to be considered is the potential clash between learner-centred pedagogy and the cultural context in which it is being implemented, especially in the lower phases of schooling (Nyambe, 2009). In most Namibian cultures, children are expected to be respectful of adults and conform to certain traditional expectations. For instance, being critical of the ideas of an adult or even questioning the ideas of an adult can be viewed as disrespectful. In most cultures, children are expected not to be
critical of adults or to question adults. While it can be argued that this situation is changing in some parts of society due to the mix of cultures, it is little changed in others. Therefore, in as much as learner-centred pedagogy subscribes to a cultural context that presents the learner as someone who is critical and questioning, it may be simply antithetic to some cultures and therefore difficult to introduce.

Conclusion

Despite the adoption of learner-centred pedagogy as the official pedagogy in post-independence Namibian classrooms, several factors still militate against its meaningful uptake. The presence of these factors suggests the persistence of traditional forms of teaching co-existing in our classrooms with more recent attempts at learner-centred pedagogy. Taking into account the critique of learner-centred pedagogy in the literature (some aspects of which were presented in the opening sections of this chapter) and also the persistently challenging context for its implementation, it could be argued that mixed pedagogical approaches constitute the route to go for now.

REFERENCES


NAMIBIA COUNTS – RATIONALE AND INTRODUCTION

Marc Schäfer, Duncan Samson and Bruce Brown

Introduction
The dissemination of academic research usually occurs through formal journal publications or through conference proceedings, but seldom do these reach the classroom teacher, the policy makers, even students and education practitioners in general. The purpose of this book is thus inter alia to make accessible research work conducted by a cohort of Namibian Masters’ students with a specific focus on Mathematics Education. Globally, Mathematics is viewed as a key curriculum domain for reasons that it empowers learners to address technological and economic imperatives, it enables learners to think critically and creatively and it develops problem solving skills, not only in a mathematical sense but also in an applied contextual sense.

Each chapter in this book was written by a selected Master’s student who participated in a Mathematics Education Master’s programme in Namibia run by Rhodes University, South Africa. This programme was established some twelve years ago and runs in two-year cycles. The focus of each chapter is very specific and homes in on a particular issue identified as pertinent and relevant to the Namibian context. The three broad themes that frame this book are learners and learning, teachers and teaching, and broader classroom practice. An overarching objective of each chapter is to avoid a negative discourse and be mindful of contributing to the improvement of Namibian mathematics education in a constructive and meaningful way.

Outline/orientation of the MEd programme
The course outline of the Rhodes University MEd (Mathematics Education) programme for Namibia states:
The overarching theme of the MEd course in Mathematics Education centres around the development and growth of critically reflexive practitioners who will actively contribute to, and have the capacity to act as, agents of change in the transformation process of Mathematics Education in Southern Africa. The underpinnings of the course outcomes are two-fold:

1. To enable and facilitate professionals to develop a broad and critical perspective on Mathematics Education in the context of their personal space, current national developments and global trends.

2. To develop research capacity through practical and theoretical engagement.

The course will be of particular relevance to:

- practicing teachers/educators
- aspiring researchers in the field of Mathematics Education
- subject advisors
- policy advisors
- educational planners
- college lecturers
- technikon lecturers
- university lecturers
- human resources practitioners
- training consultants, and
- adult basic education practitioners.

The outcomes of the course are articulated as follows:

Successful candidates should demonstrate that they have acquired at least the following outcomes in the context of Mathematics Education:

- Competences related to specialist bodies of theoretical and applied knowledge relevant to Mathematics Education
- Competences related to the practices of systematic, critical and disciplined thinking
- Competences related to the practices of Mathematics educational research with specific reference to the Namibian context.
In particular candidates will:

- integrate their learning with their practice and their personal experiences
- work both as individuals and in a team of professionals
- communicate their understanding, perceptions and research in a variety of forms
- think critically, analytically, creatively and participate actively in debates on Mathematics Education
- research topical issues within a Namibian context, using appropriate techniques and methodologies
- take ownership of their own thesis and/or research projects
- analyse, evaluate, synthesise and challenge: existing and emerging theories underpinning education both globally and nationally specifically within the context of Mathematics Education
- operate as responsible and informed agents of change in Mathematics Education in Namibia.

Based on this competency framework, the course curriculum consists of a core around which there is ample room for individuals and groups of students to explore areas of interest relevant to their own practice. The themes which guide the coursework can include:

- Mathematics as a social construct
- Philosophy of Mathematics
- Curriculum and assessment
- Investigative Mathematics and problem-solving
- Mathematics and language
- Mathematics and multi-culturalism
- Spatial conceptualization and Mathematics
- Proficiency in Mathematics teaching
- Proficiency in Mathematics
- Teacher identity
- Learning proficiency
- Learning and teaching theories in Mathematics Education

These are subject to some negotiation with students.
The MEd programme is run over a two-year period with five contact sessions in each year. The first year consists of coursework, the content of which is partly guided by the interest and needs of the students. The second year is dedicated to the research project which culminates in a 30,000 word half-thesis which is examined internally and externally. The research projects, the focus of this book, need to be approved by the Rhodes University Education Faculty Higher Degrees Committee.

**Namibia counts – Mathematics in Namibia**

Each chapter locates the research within a very specific (at times quite narrow) focus within the re/transformed Namibian Mathematics curriculum which has, as its starting point, a strongly articulated learner-centred orientation that is broadly aligned to a constructivist view of teaching and learning. The chapters elaborate and provide more details in this regard. The complex nature of what is popularly referred to as the Southern African mathematics education crisis, which is characterised by poor infrastructure, low learner performance, shortage of appropriately qualified teachers, poor governmental support, poverty, issues of health and undesirable socio-economic contexts, multiple curriculum changes etc. are well-documented and it is not the intention of this book to describe these further. Rather, each chapter critically engages with empirical data from the field and provides evidence-based recommendations as to what could be done to address and perhaps solve these complexities. The findings of each individual case study contribute to a collective sense of how mathematics education in Namibia can be transformed and why Mathematics in Namibia counts.

**Overview of the research approaches**

We consciously avoided prescribing a narrow paradigm-driven research approach to the individual research projects to encourage an emerging research culture within the group. This also applied to our aversion to prescribing a narrow research agenda as we wanted to encourage innovative and original research questions that had a close empirical relevance to the contexts of the students. At the same time we were however mindful that this approach could lead to an incoherent and eclectic research agenda, which is not desirable. As it turned out, the projects which we report on in this book centred around three themes which we elaborate on below. All the projects reported on in this book were in-depth analyses of particular situations against a backdrop of
unique contexts and issues. The researchers were all integrally associated with the research context and the data gathering process. This embodied approach to research resulted in research questions that were directly derived from their personal experiences. This naturalistic approach conveniently oriented the individual case studies in an interpretive paradigm – often making use of mixed methods (quantitative and qualitative) to gather data. Typically the research participants were small in number, purposefully selected and closely associated with the particular context of the study. The researchers mostly used semi-structured one-on-one or focus group interviews, to either follow up on questionnaire responses or observation data. Invariably documents such as curriculum and/or policy statements, lessons plans and other associated texts provided parallel data to shed light on the particular contexts. At times a situational analysis of the context was provided to establish the appropriate context of the research site and the research questions for the reader. Interviews, observations, questionnaires and document analyses were the dominant data gathering instruments that generated rich data to engage with. The analysis process and ensuing narratives invariably relied on themes that either emerged in a process of iterative reading and coding, or on pre-designed frameworks and models that were either adapted or adopted from the relevant literature review searches that the researchers engaged with during their coursework.

The themes

Learners and learning
The primary focus of this theme was on learning and homed in on three critical areas of learning Mathematics: geometry, fractions and the transition from school mathematics to tertiary mathematics. The first study in this theme arose from a general concern that learners find geometry very difficult to deal with and in particular that the level of geometric thinking of learners appears to be out of alignment with what is expected from them in the curriculum and textbooks. This study took an in-depth look at the levels of geometric thinking in selected Grade 11 learners. The second study was inspired by the assertion that the use of multiple representations in learning fractions could enhance conceptual understanding in this area. The study made use of an intervention programme to analyse how interactions between selected learners enhanced this learning. The third study in this theme focussed on the transition between school mathematics and tertiary mathematics – a
transition that many learners find very difficult to cope with. The study analysed the perceptions of a group of first year students about their own mathematical proficiency as a result of participating in an intervention programme.

**Teachers and teaching**

The primary focus of this theme was teachers and their practices. In particular, it analysed different teaching approaches, techniques within particular mathematical domains, teaching within alternative curriculums and reflecting on one’s own practice. The first study in this theme was inspired by notions of proficient teaching, particularly with regard to conceptual and procedural teaching. The study analysed the teaching of two very successful teachers who purported to adopt two very different approaches to teaching. The second study arose out of the observation that many teachers, particularly student teachers, only teach the cross-product method when solving for proportion word problems. The study used a multiple representation intervention programme to study different ways of teaching word problems of this nature. The third study involved teachers in the design and implementation of a geometry learning programme of a systematised framework of teaching phases. The study analysed how the participating teachers experienced this approach to teaching geometry. The fourth study focussed on student teachers and the difficulties they experience when teaching fractions. The fifth study was inspired by the observation that learners in Singapore consistently fare well in international mathematics assessment surveys. The focus of the study was on an intervention project in Namibia that was based on the Singapore curriculum. The sixth study was inspired by a concern that many mathematics teachers in Namibia struggle to embrace a learner-centred orientation in their teaching and persist in their traditional methods which are characterised by a chalk-and-talk style of teaching. The study investigated how selected teachers interpreted learner-centeredness’ in the teaching of Mathematics. The seventh study arose out of a conviction that reflecting on one’s practice ought to be part-and-parcel of good teaching. The study looked at three teachers who were perceived to be exemplary in incorporating reflective practice in their teaching and how this enabled them continuously to improve their teaching.
Broader classroom practice
This theme includes the investigation of finer and specific nuances of classroom practice. It sought to illuminate some facets of the complexities of classroom practice. The first study looked at the prevalence and nature of code switching practices in one region of Namibia. This practice is still stigmatised and the study sought to provide some answers to deal with this misunderstood phenomenon in the mathematics classroom. The second study focused on the teaching of multigrade classes in an attempt to provide some solutions to the implications of a more widespread roll-out of this practice in remote rural areas. The third study researched the observed discrepancies between the internal continuous assessment marks and the external end-of-year national assessment marks in Grade 10. The study engaged with the inherent tensions in these discrepancies to better understand the nature and rationale for these different types of assessment. The fourth study was inspired by the observation that the Ministry of Education finds it difficult to attract proficient markers for the assessment of the Grade 12 National Examination. The study sought to discover the extent of this problem and to find possible reasons for the prevalence of this situation. The fifth study engaged with the distribution and use of teaching aids in the majority of secondary schools in Windhoek. The study sought to research the type, nature and availability of teaching aids in secondary schools. It also engaged with teachers about their views on the availability of these aids.

Conclusion
It is hoped that the contributions in this book are of interest to all who are involved in Mathematics Education in Namibia in general, and those who are committed to its transformation. The contributions may resonate with individual teacher’s practice and inspire a process of reflection to enhance one or two aspects of that practice. They may inform policy makers as they consider policy design and implementation and assist student teachers as they sharpen their skills before entering the teaching profession. They may inspire aspiring and experienced researchers as they grapple with research questions that could lead to meaningful research in evidence based transformation of Mathematics Education in Namibia.
THEME 1

LEARNERS AND LEARNING
This case study utilised the van Hiele theory of thinking to analyse geometrical conceptualisation in 50 selected Grade 12 mathematics students. The results of this study indicated that many of the participants are at the pre-recognition van Hiele level, whereas the curriculum for Grade 12 requires students to operate at van Hiele levels 3 and 4. This misalignment is of great concern and should be addressed urgently.

Introduction

The Namibian Government attaches great importance to the teaching and learning of Mathematics and Sciences. “Mathematical knowledge and mathematical methods of inquiry constitute an essential part of and contribute to all modern science and engineering” (Namibia. Ministry of Education [MoE], 2005a, p. 2). Mathematics is viewed as more than just an accumulation of facts, skills and knowledge (Namibia. MoE, 2005b) – it is a dynamic, living and cultural product. Namibia recognises Mathematics as one of the crucial subjects necessary for the country to realise its full potential (Namibia. Mathematics and Science Teachers Extension Programme [MASTEP], 2002). A study carried out 10 years ago by the Ministry of Basic Education, Sports and Culture through the Mathematics and Science Extension Programme [MASTEP], reports that:

Namibia has achieved a great deal since Independence in the field of education. This includes projects, papers written and research
carried out in mathematics and mathematics education, many of them of the first class, but there has not been a great deal of improvement resulting from these efforts, learners still under-achieve in Mathematics.

(Namibia. MASTEP, 2002, p. 3)

This is corroborated by the results of the second report of the Southern Africa Consortium for Monitoring Education Quality (SACMEQ II) (Namibia. Ministry of Basic Education, Sports and Culture [MBESC], 2004), that revealed that Namibian Grade 6 learners as well as their teachers performed poorly in mathematics testing. Out of the 12 countries that participated in this study, Namibia’s performance of Grade 6 learners and teachers ranked last and second last respectively. Based on these findings, 25 upper primary teachers were identified from the nine circuits of the Kavango Education Region in Namibia and were trained with the help of the Academy for Educational Development (AED) under the auspices of the Basic Education Support (BES) Project III in Namibia. The training was necessitated by the notion that “the overall, low average scores for Namibian Grade 6 mathematics teachers and their learners indicates that there could be a problem with either the mathematics curriculum or the training of mathematics teachers and the way they teach the subject”. (Namibia. MBESC, 2004, p. 146)

During the training, a geometry test drawn from the question papers of the Grade 7 end-of-year examinations was administered to the teachers. Of the 25 teachers who took the test 23 i.e. 90% scored below 50% (Namibia. MoE, 2006). Two of the 23 teachers obtained zero. As one of the facilitators of this training, I realised that the majority of the upper primary mathematics teachers in the Kavango Education Region have a poorly developed proficiency in geometry.

The teaching and learning of geometry is clearly a problem in Namibia. As geometry is a key element of any mathematics curriculum it is important that it is taught proficiently. As Teppo (1991, p. 217) states “systematic geometry instruction in the middle grades is necessary to prevent students from entering high school at low levels of geometric concept development”. Having taught mathematics for ten years at the secondary phase, I learnt that although students at Grade 12 level are familiar with some of the geometric shapes, they do not understand their properties and they can hardly perform even basic informal deductions. Drawing on my own experience and the findings of the SACMEQ II report (Namibia. MBESC, 2004) I found it appropriate to conduct an in-depth study to explore the geometric reasoning of the Grade 12 students
in two selected senior secondary schools in the Rundu Circuit in the Kavango Region of Namibia.

**Aims of the research**

The purpose of this research study was thus to explore and gain an understanding of the geometrical conceptualisation in Grade 12 students in two selected schools in Namibia.

**Research questions**

Using the van Hiele theory in analysing the geometrical conceptualisation of Grade 12 students, the following research questions were pursued:

1. What are the van Hiele levels of thinking required by the Grade 12 mathematics curriculum in Namibia?
2. Are selected Grade 12 students in Namibia functioning at a level of geometric thinking that fits with their mathematics curriculum?

The difficulties encountered by students in learning geometry is not a unique problem to Namibia alone, it is a worldwide phenomenon that has existed for a long time (Snyders, 1995).

Two Dutch mathematics educators, Pierre van Hiele and his wife, Dina van Hiele-Geldof, who due to their frustrations with the teaching of geometry in their country in the 1950s, conducted an investigation to find possible reasons why students had problems in learning geometry in their classrooms. The findings of their investigations resulted in the development of a theory, which distinguished five different thought levels that students should go through when learning geometry. This theory was subsequently considered by many countries such as UK, USA and the former USSR as one of the best frameworks to assess students’ geometric reasoning (Atebe & Schäfer, 2008). This is because it provides a structure for understanding how students develop geometric concepts through appropriate learning experiences (Genz, 2006).

This theory has also attracted considerable interest among mathematics education researchers such as Usiskin (1982), Hoffer (1983), Burger and Shaughnessy (1986), Senk (1989), Siyepu (2005), Genz (2006) and Atebe and Schäfer (2008).

For example, van Hiele (1986, p. 39) explains that when teaching geometry, “it always seemed as though I were speaking a different language”. Usiskin (1982) further indicates that many students fail to grasp key concepts in geometry, and leave the geometry class without
learning basic geometric concepts. The van Hiele theory describes the geometric thinking students go through as they move from a holistic perception of geometric shapes to a refined understanding of geometric proof (van Hiele, 1986). Usiskin (1982) and Teppo (1991) indicate that the theory hypothesises five levels of understanding through which students progress.

**Literature review – the van Hiele levels of thinking**

Two different numbering schemes are used in the literature to identify van Hiele levels of thinking (Senk, 1989, p. 310). The van Hieles originally used a framework from Levels 0 through 4, a scheme consistent with the European system of numbering floors in a building: ground, first, second, and so on (Senk, 1989). However, when Wirszup (1976) and Hoffer (1979) brought the work of the van Hieles to the attention of the American audience, they used a 1 through 5 numbering scheme (Senk, 1989). Despite the fact that the Namibian Education System is founded on the basis of the Cambridge Education System, which is from Europe, I find it appropriate to use the numbering system (1–5) as used in other research studies (Pegg, 1995; Mason, 1998; Siyepu, 2005; Genz, 2006; Atebe & Schäfer, 2008). This numbering scheme allows the researcher to use Level 0 for students who do not function at what the van Hieles referred to as the ground or basic level.

**Level 1: Recognition**

The student at this level reasons about basic geometric concepts, such as simple shapes, primarily by means of visual considerations of the concept as a whole without explicit regard to properties of its components. For example, students recognise triangles, squares, parallelograms, and so forth by their shape, but they do not explicitly identify the properties of these figures (de Villiers, 1996). “While students may make mention of the length of sides or the size of angles, when directed to focus on these aspects they will not be used spontaneously without prompts” (Pegg, 1995, p. 89). Pegg (1995) further states that for students at this level, a figure is a square, cube or rectangle because it looks like one.

**Level 2: Analysis**

At this level students can analyse and describe component parts of the figures, for example, opposite angles of parallelograms are equal, but interrelationships between figures and properties cannot be explained
(Teppo, 1991). Students reason about basic geometric concepts by means of an informal analysis of component parts and attributes (Burger & Shaughnessy, 1986). According to Teppo (1991), students at this level begin to identify properties of shapes and learn to use appropriate vocabulary related to properties, but do not make connections between different shapes and their properties. This means that irrelevant features, such as size or orientation, become less important, as students are able to focus on all shapes within a class. For example, “an isosceles triangle can have two equal sides, two equal angles and an axis of symmetry but no property implies another” (Pegg, 1995, p. 90). At this level properties are seen as separate entities that cannot be combined together to describe a specific figure. Properties of figures are not yet ordered. This means that students at this level are unable to make short deductions (Clements, 2004, p. 62).

**Level 3: Ordering**

At this level, students are able to logically relate previously discovered properties or rules by giving or following informal arguments such as “drawing, interpreting, reducing, and locating positions” (Feza & Webb, 2005, p. 38). Students at this level should begin to see “how one figure could be characterised by several different names” (Pusey, 2003, p. 14). For example, a square is seen as a rectangle, but a rectangle is not necessarily a square. Mayberry (1983, p. 59) states that “logical implications and class inclusions are understood”. However, the role and significance of deduction is not yet understood.

**Level 4: Deduction**

At this level deduction becomes meaningful. For example, Hoffer (1981) explains that the student understands the significance of deduction and the role of postulates, axioms, theorems and proofs. Pegg (1995) states that at this level students should be able to supply reasons for steps in a proof and also construct their own proof and the need for rote learning is minimised.

**Level 5: Rigour**

This is the highest level of thought in the van Hiele hierarchy (Teppo, 1991). Students at this level can work in different geometric or axiomatic systems and would most likely be enrolled in a college or university level course in geometry (Teppo, 1991; Pegg, 1995).
Research methodology

The research study is largely situated in the interpretive paradigm and utilises a case study approach. The research study was conducted in the Rundu Circuit in the Kavango Region of Namibia where two senior secondary schools (A and B) were purposefully selected from the 22 schools in the circuit. Only one Grade 12 class was used at each school. There were 20 students in the class for School A and 30 students for School B. The mean age profile and the number of the participants are presented in Table 1 below.

Table 1: Number and mean age of the participants

<table>
<thead>
<tr>
<th>School</th>
<th>Number of participants</th>
<th>Mean age (in yrs)</th>
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<tbody>
<tr>
<td></td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>A</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>23</td>
<td>7</td>
</tr>
<tr>
<td>Totals</td>
<td>33</td>
<td>17</td>
</tr>
</tbody>
</table>

Instruments

For the overall study data was collected through documents, tests and clinical interviews. But for the purpose of this chapter the focus will only be on the van Hiele Geometry Test.

The van Hiele Geometry Test, as constructed by staff of the Cognitive Development and Achievement in Secondary School Geometry (CDASSG) (Usiskin, 1982), and adapted by Atebe and Schäfer (2008), was adopted with their permission. The reasoning for adopting the adapted version of the van Hiele Geometry Test was because it was appropriately content specific. Van Hiele (1986) and Senk (1989) suggest that studies that seek understanding of the thinking processes that characterised the van Hiele levels of geometric reasoning should be content specific. The other reason for using the adapted version of the CDASSG test was because it was relevant to the Namibian situation. The adapted test contained those aspects of the themes/topics prescribed for geometry in the mathematics syllabus for the Namibia Senior Secondary Certificate (Ordinary and Higher levels) [NSSC (O/H)]. These themes/topics are: geometrical terms, geometrical construction, symmetry, angle properties and locus (Namibia. MoE, 2005a, pp. 6-7).
The initial CDASSG test in Usiskin’s (1982) project was developed to assess or determine all five van Hiele levels of geometric reasoning, but the adapted version contained test items that could only investigate the attainment of the first four van Hiele levels. This is because many researchers (van Hiele, 1986; Burger & Shaughnessy, 1986; Senk, 1989; Pusey, 2003; Siyepu, 2005; Genz, 2006; Atebe & Schäfer, 2008) suggest that the highest van Hiele level attainable by a student in formal education is ideally van Hiele level 4. The adapted van Hiele Geometry Test consisted of four subtests, each with five multiple-choice items based on each of the van Hiele levels. In total there were 20 items, with numbers 1–5 testing the attainment of van Hiele level 1, 6–10 testing level 2, 11–15 testing level 3 and 16-20 testing level 4.

There were many success criteria suggested by Usiskin (1982, p. 23). In this study however, only the “3 of 5” criterion was used. This criterion means that if a student answered correctly at least 3 out of 5 items in a given subtest, that student was considered to have mastered that level. Usiskin (1982, p. 22) further developed a grading system to assign weighted sum scores for each student. This grading system was adopted in this study and comprised:

- 1 point for satisfying criterion on items 1–5 (level 1)
- 2 points for satisfying criterion on items 6–10 (level 2)
- 4 points for satisfying criterion on items 11–15 (level 3)
- 8 points for satisfying criterion on items 16–20 (level 4)

Thus, the maximum score obtainable by any student was $1 + 2 + 4 + 8 = 15$ points. The weighted sum score for each participant was worked out using the grading system above. The weighted sum scores were then used to assign the participants to the van Hiele levels of geometric thinking. A student was considered to be at the pre-recognition level, if that student’s weighted sum score was 0, 2, 4, or 8. For the weighted sum of 2, the student got at least 3 out of 5 only at level 2. But because of skipping level 1, that student was classified under the pre-recognition level. For the weighted sum of 4, the participant obtained at least 3 out of 5 only at level 3, and for the weighted sum of 8 the participant obtained at least 3 out of 5 only at level 4. The student with a weighted sum of 4 or 8 is at the pre-recognition level because of skipping levels 1 and 2 for the weighted sum of 4 or levels 1, 2 and 3 for the weighted sum of 8. This process was continued with the weighted sums for the van Hiele levels 1, 2, 3 and 4.

**Assignment of levels:** Using the 3 of 5 correct success criterions, two methods were used to assign students to levels as follows:
Classical and modified van Hiele levels: A student’s van Hiele level was defined to be the highest consecutive level (beginning from level 0) he or she has mastered. If, for example, a student satisfies the criterion at levels 1, 2 and 4, he or she would be assigned to van Hiele level 2. Usiskin (1982) would only assign modified van Hiele level 2 to such a student, but would not classify the student—for skipping level 3—under the classical theory. (Atebe & Schäfer, 2008)

Forced van Hiele levels: Usiskin (1982, p. 34) assumed that the “fixed sequential nature of the levels is valid”, and therefore believed that a student whose responses “do not fit the sequence is probably demonstrating random fit”. As a result, a method was developed for assigning levels to such students as follows: A student is assigned to level n if “(a) the student meets the criterion at levels n and n – 1 but perhaps not one of n – 2 or n – 3, or (b) the student meets the criterion at level n, all levels below n, but not at level n + 1 yet also meets the criterion at one higher level” (Usiskin, 1982, p. 34). This criterion allows for more students to be assigned into levels.

Findings

Assignment of van Hiele levels of geometric thinking
Usiskin (1982, p. 99) proposed a schematic description of 32 possible profiles of meeting or not meeting the criteria at the five van Hiele levels together with the corresponding weighted sum and assignment of forced van Hiele levels. For this study, the schematic description was adapted to give 15 profiles as presented in Table 2 and Table 3. This was done because the research participants are Grade 12 students, who are ideally expected to function up to van Hiele level 4.
Table 2: Schematic description and number of students at each of the forced van Hiele assignment, School A subsample.

<table>
<thead>
<tr>
<th>Weighted sum</th>
<th>Level</th>
<th>3 of 5 criterion</th>
<th>Total (%) at level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forced VHL0 = 0C0, M0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>x</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>x</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>x</td>
<td>1</td>
<td>7(35)</td>
</tr>
<tr>
<td>Forced VHL1 = 1C1, M1</td>
<td>x</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>x</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>x</td>
<td>0</td>
<td>5(25)</td>
</tr>
<tr>
<td>Forced VHL2 = 3C2, M2</td>
<td>x</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>x</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>x</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>15C4, M4</td>
<td>x</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Forced VHL3 = 6C3, M3</td>
<td>x</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>x</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Forced VHL4 = 13</td>
<td>x</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>x</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>15C4, M4</td>
<td>x</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Forced No Fit = 10</td>
<td>x</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>x</td>
<td>0</td>
<td>0(0)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>20(100)</td>
</tr>
</tbody>
</table>

NOTE: An x indicates that the student has met the criterion at that level.

Table 2 indicates that of the 20 (3 students were absent) School A students that participated in this research study, 7(35%) were at the pre-recognition level of geometric thinking. 5 (25%), 6 (30%) and 2 (10%) were respectively found at van Hiele levels 1, 2 and 3. None of the students reached van Hiele level 4.
Table 3: Schematic description and number of students at each level of the forced van Hiele assignment, School B subsample.

<table>
<thead>
<tr>
<th>Weighted sum</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>3 of 5 criterion at level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forced vHL0 = 0C0, M0</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2 7</td>
<td></td>
<td></td>
<td></td>
<td>12(40)</td>
</tr>
<tr>
<td>Forced vHL1 = 1C1, M1</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>5 1</td>
<td></td>
<td></td>
<td></td>
<td>6(20)</td>
</tr>
<tr>
<td>Forced vHL2 = 3C2, M2</td>
<td>x x</td>
<td></td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>11 1</td>
<td></td>
<td></td>
<td></td>
<td>7(23.3)</td>
</tr>
<tr>
<td>Forced vHL3 = 6C3, M3</td>
<td>x x</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>7 2</td>
<td></td>
<td></td>
<td></td>
<td>2(6.7)</td>
</tr>
<tr>
<td>Forced vHL4 = 13C4, M4</td>
<td>x x x</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>14 1</td>
<td></td>
<td></td>
<td></td>
<td>1(3.3)</td>
</tr>
<tr>
<td>Forced No Fit = 10</td>
<td>x x</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>12 1</td>
<td></td>
<td></td>
<td></td>
<td>2(6.7)</td>
</tr>
</tbody>
</table>

**Total** 30(100)

NOTE: An x indicates that the student has met the criterion at that level.

Table 3 shows that of the 30 (all students were present) School B students who participated in this research study, 12(40%) were found at the pre-recognition level of geometric thinking. 6(20%), 7(23.3%), 2(6.7%) and 1 (3.3%) respectively were functioning at van Hiele levels 1, 2, 3 and 4 of geometric thinking.
Table 4: Number and percentages of students at each of the forced van Hiele levels

<table>
<thead>
<tr>
<th>Level</th>
<th>School A</th>
<th></th>
<th>School B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>0</td>
<td>7</td>
<td>35</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>25</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>30</td>
<td>7</td>
<td>23.3</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>6.7</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Fitting</td>
<td>20</td>
<td>100</td>
<td>27</td>
<td>90</td>
</tr>
<tr>
<td>No Fit</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>100</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

From Table 4 above it can be seen that all 20 (100%) of School A participants are assignable to van Hiele levels, compared to the participants of School B, where 28 (93.3%) are assignable and 2 (6.7%) do not fit the criteria for classification. A further analysis was carried out to determine the distribution of the School A and School B students into the van Hiele levels according to the classical/modified van Hiele levels.

Table 5: Number and percentage of School A and School B students at each of the classical/modified van Hiele level

<table>
<thead>
<tr>
<th>Classical/Modified van Hiele Levels</th>
<th>School A</th>
<th></th>
<th>School B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Levels</td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>0</td>
<td>7</td>
<td>35</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>25</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>30</td>
<td>7</td>
<td>23.3</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>6.7</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Fitting</td>
<td>20</td>
<td>100</td>
<td>27</td>
<td>90</td>
</tr>
<tr>
<td>No Fit</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>100</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 5 shows that using the (3 out of 5) modified van Hiele theory, all (100%) of the School A students are assignable to the van Hiele levels. The table further indicates that using the same theory, only 27 (90%) of School B students are assignable to van Hiele levels of geometric thinking, with none of them reaching van Hiele level 4.

**Assignment of the participants to van Hiele levels using the modified van Hiele levels (3 out of 5).**

The bar graph in the figure below displays how the participants were assigned to van Hiele levels using the modified van Hiele levels. Usiskin (1982, p. 79) refers to the van Hiele theory with level 5 as the “classical theory”, while the theory without level 5 is called the “modified theory”. This study uses the modified theory for the reason that level 5 was not part of the adapted CDASSG test.

**Figure 1A: Bar graph of the assignment of participants to modified van Hiele levels.**

![Assignment of Van Hiele levels](image)

The figure shows that 40% of the participants from School B, compared to the 35% of the participants from School A, were at the pre-recognition level. The graph reveals that the percentage of participants at level 2 in both schools is more than that at level 1. In School A, 25% of participants were at level 1 and 30% were at level 2. In School B, 20% were at level 1 and 23.3% were at level 2. The graph further depicts that 10% of...
participants in School A and 6.7% of participants in School B were at level 3. None of the participants from the two schools was at level 4 as per modified van Hiele levels.

**Participants’ performance at each van Hiele level**
The bar graph in Figure 1B below presents the performance of the research participants in each subtest of the van Hiele Geometry Test.

**Figure 1B: Bar graph of the performance of the participants at each van Hiele level in percentages**

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>School A</td>
<td>60</td>
<td>40</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>School B</td>
<td>50</td>
<td>45</td>
<td>30</td>
<td>15</td>
</tr>
</tbody>
</table>

The bar graph shows that School A performed better in subtests 1 and 3. The participants from School A obtained 55% and 34% in the subtests of levels 1 and 3 compared to the 45.3% and 31.3% obtained by the participants from School B in the same subtests. On the other hand, School B outperformed School A in subtests 2 and 4. The graph shows that School B obtained 54.7% and 32% in subtests 2 and 4 respectively, while School A obtained 52% and 27%.

**Discussion**
The results of this study provide an interesting overview of a sample of two Namibian Grade 12 students’ geometrical conceptualisation that is consistent with the van Hiele theory of geometric thinking levels. It is clear from the results that students conceptualise, reason and function at different levels with reference to geometric concepts.
Generally, any Grade 12 geometry curriculum globally requires students to function and operate up to van Hiele level 4. But results of this study reveal that most of the Grade 12 students function only up to van Hiele level 2.

From Figure 1A, it can be seen that 10\% of participants in School A and 6.7\% of participants in School B were at van Hiele level 3. And none of the participants from the two schools was at level 4 as per the 3 of 5 of the modified van Hiele levels.

The findings presented in Figure 1A concur with those of other research studies (Usiskin, 1982; Burger & Shaughnessy, 1986; Senk, 1989; Pusey, 2003; Siyepu, 2005; Atebe & Schäfer, 2008). The findings of the studies mentioned here indicated that the majority of their research participants were found to be operating at the pre-recognition level, and that a very small number of the students operated at van Hiele levels 3 and 4. This is problematic, as in Namibia, level 3 skills are required to successfully complete the Grade 12 syllabus. Teaching and learning in geometry is mainly focused on van Hiele levels 1 and 2, with a small amount of geometry work being done at level 3. The results of this research study show that most participants only operate on the pre-recognition, 1 and 2 levels. This means that the students do not function up to the van Hiele level required by the curriculum.

**Conclusion**

Geometry is an important branch of mathematics as it:

- develops skills of applying geometry through modelling and problem-solving in real world contexts,
- encourages the development and use of conjecture, deductive reasoning and proof.

(Royal Society/JMC, 2001)

These reasons suggest that a student who has strong content knowledge of geometry stands a good chance of performing well in Mathematics in general. This study sought to provide an understanding into the geometrical conceptualisation of selected Grade 12 students in Namibia. It utilised the van Hiele theory to determine the levels of geometric thinking of the students. The results of this study revealed that many of the research participants have a very poor conceptual understanding of geometry as 35\% participants from School A and 40\% of the participants School B were at the pre-recognition level. The challenge for Namibian schools is thus to align the teaching and learning of geometry to the
expectations of the curriculum. The notable disjuncture between the van Hiele levels as required by the curriculum and what is happening on the ground is reason for concern and needs urgent attention.

REFERENCES


THE USE OF MULTIPLE REPRESENTATIONS IN SOCIAL INTERACTION TO PROMOTE THE LEARNING OF PERCENTAGES AND FRACTIONS

MARIO NGOLA

This chapter discusses research on a learning and teaching intervention programme to enhance conceptual understanding of fractions and percentages through the use of multiple representations. The programme also promoted learning through social interaction. The research demonstrated that using multiple representations could promote the learning of percentages and fractions. In this programme, both the interactions between teacher and learner as well as the interactions between learner and learner contributed to enhancing conceptual understanding.

Introduction

In Namibia, according to national reports from 2011, 48.5% of learners failed Grade 10, thereby halting their education (Smit, 2011). Furthermore, 53.3% of the Grade 10 learners failed Mathematics (Smit, 2011). In trying to find the root of this problem, we see that 59% of upper primary learners are also failing Mathematics (Sasman, 2011). This suggests that learners do not attain a proper grasp of the foundations of the subject from an early age.

The Report of the Southern and Eastern Consortium for Monitoring Educational Quality Project (Namibia. SACMEQ, 2000, 2007) shows that learners in Namibia do not perform well in the topics of fractions and percentage. The Report on the National Examination for the Grade 10
candidates for 2011 stated that many learners answered topics such as algebra, geometry, money and finance correctly, but that topics such as percentages, fractions, ratio and proportion and probability proved a challenge to the majority of the learners (Namibia. DNEA, 2012). Percentages and fractions form an important part of the Namibian Grade 8 syllabus. Learners need to acquire greater understanding of these topics so that in Grade 10 they can build on this foundation to learn topics like proportion, ratio and probability. In my teaching experience, I have observed that learners lack conceptual understanding of percentages and fractions – they appear to develop mainly procedural skills in this domain. A contributing factor may be the teachers’ use of instructional approaches that do not encourage social interaction.

This chapter discusses research on a learning and teaching intervention programme aimed to enhance conceptual understanding of fractions and percentages. The programme included the use by learners of multiple representations such as the real world, written symbols, spoken symbols, diagrams and manipulatives, and it promoted the learning of percentages and fractions through social interaction.

The aim of the study
This study investigated the extent to which multiple representations and social interaction may be used to enhance the learning of percentages and fractions by Grade 8 learners in a Namibian school. A teaching and learning programme incorporating these was developed and implemented by the researcher. The effect of the implemented programme was the main focus of the research.

The overall question
How did the teaching and learning programme promote, or not promote, the learning of percentages and fractions?

This question was addressed by means of the following sub-questions:

1. How did the use and manipulation of multiple representations as tools by the learners influence the learning process?
2. How did the teacher influence the dynamic learning interaction process in ways that promoted or did not promote learning?
3. What learners’ interactions that were not strongly mediated by the teacher promoted or did not promote the learning of percentages and fractions?
These three questions are strongly inter-related but for the purpose of analysis they provided different and complementary perspectives on the teaching and learning process.

**Literature review**

Haas (1998) stated that learners’ lack of conceptual understanding of fractions is a direct result of inadequate and inappropriate instruction on fractions. As a result, the connections between manipulative representations and symbolic representations are not effectively developed. Kilpatrick, Swafford and Findell (2001) argue that interaction, in an instructional triangle of the teacher, the students, and the mathematics, develops proficiency in Mathematics. Building on these concerns I used two instructional orientations to develop learners’ proficiency in fractions and percentages.

The first orientation was to use multiple representations in the learning and teaching of fractions and percentages. Many researchers strongly recommend the use of multiple representations in order to help students understand mathematical concepts in depth (Ball, 1988; Edgardo, 2001; Kaput, 1989). Edgardo (2001) states that multiple representations provide opportunities for learners to make connections and realize the relationships between what they are learning and their experiences, or prior knowledge. Dufour-Janvier, Bednarz and Belanger (1987) say that multiple representations can be used to “mitigate certain difficulties through multiple concretizations” (pp. 110-11). Similarly, Rau, Aleven and Rummel (2009) point out that multiple representations of learning content may enhance student learning in complex domains, when compared to learning with only single representations. Rau, et al. (2009) have shown that students learned more with multiple graphical representations of fractions than with a single representation, however this only occurred when students were prompted to explain how the graphics related to the symbolic fractions representation. They concluded that concrete models can help students represent numbers and develop number sense; they can also help bring meaning to students’ use of written symbols and can be useful in building place-value concepts. Moreover, Kilpatrick et al. (2001) said that multiple representations such as manipulates can enhance students’ understanding and help students correct their own errors.
The use of multiple representations in isolation does not promote mathematical proficiency, as multiple representations only become representations when someone gives them meaning by interpreting them (Van Someren, Reimann, Boshuizen & De Jong, 1998). They become useful when they are used as mediating tools within the learning interaction process (Vygotsky, 1978). Tools (conceptual and manual) are seen as central in mediating between the person and the world and for the development of a person’s competencies (Hedegaard, 2001). For this reason, this study investigated meaningful learning as a product of interaction between the teacher as a mediator, other learners as influences, and multiple representations as mediating artefacts or tools.

The second orientation is to move from a traditional theory of learning such as transmission, whereby the teacher transmits knowledge and the student learns by listening or copying exactly what the teacher has to say, to learning as participation in social communities and developing competence (Hedegaard, 1999). In this approach, the child is seen as a participant in learning, playing an important role in the interaction between herself/himself, the teacher as a mediator, other learners as influences and multiple representations as mediating artefacts. Vygotsky’s (1978) theory stresses the fundamental role of social interaction in the development of cognition; he strongly believed that community plays a central role in the process of “making meaning”. He further states that learning is strongly influenced by social interaction, which takes place in meaningful contexts (Van Der Stuyf, 2002). Children’s interaction with more knowledgeable others and their environment has a significant impact on their ways of thinking about and interpreting situations. That is, a child develops his/her intellect through internalizing concepts based on his/her own interpretation of an activity that occurs in a social setting. The communication that occurs in this setting with more knowledgeable or capable others (MKO) helps the child to construct an understanding of the concept (Bransford, Brown & Cocking, 2002). Vygotsky further states that a person’s potential for learning lies in their zone of proximal development (ZPD). In order to promote development, a learning activity that occurs in a social setting should fall within the ZPD of the child (Vygotsky, 1986). For this reason, this study involved research into activities that encouraged interaction between the learning child and MKO (teacher and other capable learners), and by doing this, created a zone of proximal development.
Methodology

This study was a qualitative investigation and was conducted within the interpretive paradigm, a paradigm that seeks to understand the meaning attached to human actions (in this case, learning through multiple representations when presenting percentages and fractions). Using this paradigm involved a thorough engagement with the data on how the participants interacted, interpreted and related to the work with multiple representations. I used five research tools to collect my data namely; pre and post diagnostic tests, observations, focus group interviews, learners’ work and the teacher’s journal.

The purpose of the diagnostic pre-test was to determine learners’ prior knowledge for the design and implementation of the intervention programme, while the diagnostic post-test and learners’ work were used to analyze the effect of the intervention programme. The interviews were mainly to explore learners’ understanding and feelings about the multiple representations and social interactions in the programme. The observations were used to investigate how multiple representations did, or did not, promote the learning of percentages and fractions. The teacher’s journal was used to record and reflect on any relevant information gathered in each lesson observed.

Findings and discussion

Learners attained a good grasp of the topics of percentages and fractions through the use of multiple representations, teacher and learner interactions, and learner to learner interactions.

Multiple Representations

Multiple representations showed positive effects on the learning of percentages and fractions.

⇒ Learners were able to look at representations in useful ways
⇒ A representation clarified some aspects of a concept
⇒ Multiple representations made it easier for learners to correct their own errors
⇒ The use of calculators contributed to learners’ conceptual understanding of percentage and fractions
Teacher and Learner Interactions
Interactions between the teacher and learners were important in the learning process. Three particular types of interaction were seen to positively influence the process. These were:

⇒ Learners changed words to change focus
⇒ Learners made links between the concepts learned
⇒ Learners deepened their content knowledge and conceptual understanding of percentages and fractions

Learner to Learner Interactions
There were interactions between learners themselves that promoted the learning of percentages and fractions. These were not strongly mediated by the teacher; in particular, learning through exploratory talk was important for the learning process.

i. Multiple representations
Multiple representations allowed learners to visualize concepts clearly. They learned how to use visual diagrams and real world examples to help them reason through the process of making sense and solving difficult problems. Aspects of these problems became clearer and learners were able to easily identify errors made in their calculations. Moreover, the use of calculators contributed to learners’ conceptual understanding of percentages and fractions. The study provided empirical data to support the research findings reported by Edgardo (2001) and Kaput (1989) that multiple representations help students understand mathematical concepts in depth, and develop number sense (Rau et al., 2009).

ii. Teacher and learner interactions
The teacher positively influenced the learning process by prompting learners to change words to change focus. For example, learners were accustomed to using the word “over” when reading and writing fractions – referring to the line in the fraction symbol. The focal action of the word “over” was on the written symbol and the learners’ actions were reliant on placing or writing “something over something”. The teacher helped to change the students’ focus by encouraging learners to use the phrase “out of” rather than “over”. The focal action of the learners arising from the phrase “out of” relates to an action such as removing a portion from a box – fitting the meaningful action in the problem situation, rather than the writing of the abstract symbol. Through this activity the teacher
helped learners to see the manipulatives (11 boxes) in ways that 
encouraged an understanding of the situation.

This study data supported the research findings of Vygotsky (1986) 
that the use of tools, and the potential they offer, structures the way we 
see actions and potential actions. For the learners the meaning of the word 
“out of” related to both the experience of writing the symbols and the 
practical experience of taking out of a box. This also supports the research 
findings of Bransford, Brown and Cocking (2002) that communication 
that occurs in a social setting with a more knowledgeable other may help 
the child construct an understanding of the concept.

The teacher’s appropriate guidance on how to use manipulatives helped 
students to build links between the concepts learned. After the teacher 
helped learners change the word to change their focus, the learners built 
links between the new concept “out of” and the concept of “divide by”. 
Research by Ball (1992) also supports this finding – that the teacher’s 
appropriate guidance on how to use manipulatives helps students to build 
links between the object, the symbol, and the mathematical idea being 
presented.

Furthermore, the teachers’ mediation through social interaction 
helped the learners to deepen their content knowledge and conceptual 
understanding of percentages and fractions. Learners could convert 
between percentages and fractions using multiple representations, they 
could work out a percentage of a quantity and they could express one 
quantity as a percentage of another one. Learners deepened their concepts 
of percentages and fractions through social interactions in meaningful 
contexts, as Vygotsky suggested would occur (Raymond, 2000). Here, the 
teacher mediated an interaction that formed a zone of proximal 
development for the child. Learners were actively involved in the 
interactions and they were motivated. The teacher also scaffolding 
learning that allowed the learners to perform practical and meaningful 
action. Obukhoval and Korepanova (2009) see scaffolding as a point of 
structure for performing an action.

iii. Learner to learner interactions

Learners’ interactions that were not strongly mediated by the teacher also 
promoted the learning of percentages and fractions, particularly through 
learners’ exploratory talk. This is a specific form of conversation that 
recognises each person’s contribution and encourages the reasoned 
exploration of justifying reasons for, and implications of, statements made 
by each party (Mercer, Wegerif & Dawes, 1999). In this way, exploratory
talk promotes the development of reasoning. In this study, reasoning was promoted through learner to learner interactions involving discussions, by learners pointing out reasons why they used a certain representation to identify more equivalent fractions, by learners disagreeing and agreeing with each other’s reasons, and by learners listening to each other, and giving each other a chance to speak. Through these interactions, learners were able to identify more equivalent fractions of a given one, and also increase and decrease a given quantity by a specified percentage.

Conclusion

On the basis of this research it can be concluded that the programme promoted the learning of percentages and fractions through teaching that combined three effective teaching components. The first component was the use of multiple representations. The second component incorporated interaction between the teacher and learner (focussing meaningfully on the situation and representation in ways that related to the mathematics), and the third component relating to the interaction between the learners (exploratory talk), were important for effective learning via the use of multiple representations.

The research showed that the programme enhanced the learning of percentages and fractions, that learners become fully engaged in the lessons and that they were motivated because of the use of multiple representations. It also showed that particular teacher and learner interactions were important during the process of learning about percentages and fractions. I would recommend that teachers use these three effective approaches when teaching percentages and fractions to promote the learning of the concepts.

REFERENCES


In this study I investigated the perceptions of first year mathematics students towards an alternative mode of delivery intervention programme at the University of Namibia. The alternative mode intervention programme implements a slower pace of teaching, accommodating student needs and background gaps. Lecturers developed specific teaching strategies that afforded students individual attention, greater interaction, mediation and tutorial sessions. I report on the students’ and lecturers’ responses to focus group discussions and interviews respectively. Students identified that mathematical proficiency was central to their learning, and pedagogical knowledge and exploratory talk were critical aspects of good teaching in a mathematical intervention programme.

**Introduction**

According to the University of Namibia (UNAM) Science Faculty (2010), the first year of study of Mathematics at University of Namibia has been problematic for the past 10 years. The majority of the students are unable to cope with the first year modules in Mathematics, and as a result the pass rates are unacceptably low. Many students fail these modules even after repeating them. The main reasons attributed to the poor performance are seen as a flawed high school curriculum, the lack of teaching aids, and poorly qualified teachers at high schools. As a result, the mathematical content required for first year mathematics was not adequately taught in high school.

Historically, a number of attempts have been made to overcome this shortcoming, but none has yielded improved performance. The University of Namibia Science Faculty was thus prompted to introduce a two-mode intervention programme in first year Mathematics, namely the normal
mode and the alternative mode intervention. The alternative mode intervention was designed to improve the Mathematics achievement of first year students who are considered low achieving or at risk of failure. The first year Mathematics students on the alternative mode of delivery intervention are enrolled for the B.Sc. or B.Ed. Honours degrees. For some students, Mathematics is a prerequisite subject in the course, however for others Mathematics is not. According to the UNAM Science Faculty (2010), as from 2011, all students who register in the faculty of Science sit for the first class test in Mathematics which is held after four weeks of teaching. Those who score a mark of at least 40% will be admitted to the three standard first year Mathematics modules. Those who score a mark of less than 40% are admitted to the alternate mode intervention programme.

This study aims to understand, inform and to ultimately contribute to, effective insights into the learning of Mathematics in the alternative mode intervention programme. In addition, it may possibly inform other constructive interventions in higher Mathematics education. The research project was conducted at the main campus of the University of Namibia, in Windhoek. The researcher is a high school Mathematics teacher and a former student at UNAM.

**Aim of the research**

The aim of this research was to investigate the influence of the alternative mode of delivery on students’ learning and development of mathematical proficiency. This involved developing an understanding of how the teaching and learning context of the alternative mode intervention programme supported effective student learning. The focus was on the experiences of the individuals who formed part of the intervention programme and the meaningful insights they gained of their learning experiences. The following specific research questions were posed.

1. What are the experiences of first year Mathematics students in the alternative mode of delivery?
2. What influence does the alternative mode of delivery have on the student learning experience?
3. How does this student learning experience influence their development of mathematical proficiency?
4. What are the potentials of the alternative mode intervention as a vehicle for first year Mathematics teaching?
Literature review

Many university students find themselves mathematically underprepared for their chosen field of study. Godden and Pegg (2003) identified three reasons for this: firstly, the mathematical skills of the students are deficient; secondly, the depth of their exposure to various mathematical topics is limited; and thirdly, there is an increasing reliance on mathematical techniques and concepts in subjects and courses not traditionally mathematically orientated. In addition, the gap between school and university Mathematics seems to be larger than in other subjects (Tall, 1991). Gordon and Nicholas (2011) state that the challenges of teaching an increasingly diverse cohort in higher education are felt in every discipline, but arguably more so in Mathematics.

Gordon and Nicholas (2012) state that the transition from secondary education to tertiary education is an area of particular research interest. Leviatan (2008) conjectured that there is a distinct cultural gap between school Mathematics and tertiary Mathematics. Many first year college students find it difficult to adapt to a culture where concepts are abstract, yet require rigorous definitions, and where theorems have to be proved and their assumptions meticulously verified before their results can be applied (Leviatan, 2008). According to Jennings (2009) numerous universities are investigating the problem and trying to improve this transition. Varsavsky (2010) argues that in order to attract more students to Mathematics and mathematics-based disciplines, and to improve retention, universities have been addressing the under-preparedness in Mathematics of their incoming students with bridging or remediation programmes and, more generally, with programmes that support the student transition from secondary school to university Mathematics study. Bryant, Bryant, Gersten, Scammanca and Chavez (2008) stipulated that without early identification, intervention and progress monitoring to determine students’ response to interventions, many students with mathematics difficulties may not develop a level of mathematics automaticity that is necessary for becoming proficient in Mathematics.

Knowing how to teach Mathematics well to students with differing abilities seems to be much more important than having Mathematics teachers who possess a strong background in Mathematics (Ball, Lubienski & Newborn, as cited in Baker, Gersten & Lee 2002, p. 56). Instructors need to have a vast repertoire of effective lecturing methods on hand (Jungic, Kent & Menz, 2006). A synthesis of empirical research
on the teaching of Mathematics by Baker, et al. (2002) adds that using peers as tutors or guides may enhance achievement. The use of peers to provide feedback and support improves low achievers’ computational abilities and holds promise as a means to enhance problem-solving abilities (Baker, et al., 2002).

The findings of a study by de Caprarriis, Barman and Magee (as cited in Carpenter, 2006) suggest that lecturing leads to the ability to recall facts, while discussion produces higher level comprehension. Effective teaching can be achieved by preparing typed lecture notes for students in advance and then using time efficiently in a large class (Jungic, et al., 2006). In contrast, in this research which examined perceptions across six teaching methods (lecture/discussion, lab work, in-class exercises, guest speakers, applied projects, and oral presentations), most students preferred the lecture/discussion method (Jungic, et al., 2006). In terms of students’ preferences for teaching methods, a study by Samson, Sewry and Southwood (2011) suggests that students preferred team teaching methods. Having two lecturers with different but complementary styles was cited as strengthening the class’s overall confidence towards the subject.

Kilpatrick, Swafford and Findell (2001) suggested that teachers should play a more active instructional role in helping students build mathematical proficiency than they currently do. Kilpatrick, et al. (2001) formulated the concept of mathematical proficiency to capture all aspects of expertise, competence, knowledge, and facility in Mathematics which they believe are necessary for anyone to learn Mathematics successfully. Mathematical proficiency consists of five components or strands and these strands are not independent, but rather are interwoven and interdependent. For this reason, mathematical proficiency is not a one-dimensional trait, and it cannot be achieved by focusing on just one or two of these strands. The strands of mathematical proficiency are:

- **Conceptual understanding** – relating to a comprehension of mathematical concepts, operations, and relations.
- **Procedural fluency** – referring to knowing, selecting and performing calculations and procedures or skills.
- **Strategic competence** – referring to the ability to formulate, represent, and solve mathematical problems.
- **Adaptive reasoning** – referring to the capacity for logical thought, reflection, explanation, and justification.
- **Productive disposition** – referring to a habitual inclination to see
Mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy.

(Kilpatrick, et al., 2001, p. 5)

Kilpatrick, et al. (2001) remark that the teaching and learning of Mathematics is the product of interactions among the teacher, the students, and the mathematics. This is illustrated in the instructional triangle, shown in Figure 1. If students are to develop the capacity of high-level thinking in a variety of academic domains, then classrooms must become environments in which they have frequent opportunities to engage in dynamic mathematical activity that is grounded in rich, worthwhile mathematical tasks (Schoenfeld, 1994).

**Figure 1: Instructional triangle**

Instruction can best be examined from the perspective of how teachers and students interact with content in contexts to produce teaching and learning (Kilpatrick, et al., 2001). The tasks in which students engage
provide the contexts in which they learn to think about subject matter (Stein & Henningsen, 1997).

Wegerif and Mercer (1997) chronicle their definition of exploratory talk from the outcome of the SLANT (Spoken Language and New Technology) project, which observed children engaged in computer-based joint activities in 12 British primary schools (as described in Mercer, 1995). Mercer (1995) defines exploratory talk as follows:

Exploratory talk is that in which partners engage critically but constructively with each other’s ideas. Statements and suggestions are sought and offered for joint consideration. These may be challenged and counter-challenged, but challenges are justified and alternative hypotheses are offered. In exploratory talk, knowledge is made publicly accountable and reasoning is visible in the talk.

(p. 25)

Wegerif and Mercer (1997) used the terms ‘logical’, ‘rational’ or ‘reasonable’ to describe a person who could make appropriate, clear and useful contributions to discussions, in ways that enabled solutions to shared problems to be achieved.

Methodology
The research investigation was conducted in three different phases. Firstly, 50 students completed a questionnaire. Secondly, focus group discussions were held with 12 volunteer students. Thirdly, interviews were conducted with 6 lecturers who were teaching on the intervention programme. The data collection for the second and third phases was through interviews, focus group discussions and lecturer interviews. The author used a phenomenographic approach for data analysis as this method allows for the discovery of different qualitative categories of descriptions (Morton & Booth, 1997).

The University of Namibia ethics committee approved the study and all participants gave their written consent.

Findings and discussion
The mode structure appeared to have an impact on student learning. Figure 2 shows how the students’ experience on the programme influenced their learning experience and how this impacted on their development of proficiency.
Students enjoyed and appreciated the tutorial sessions, and group work was an important aspect of this programme. Students reported that they appreciated working with other students in collaborative small groups in mathematical learning. More rules and justification of one’s work were explored, which led to more reasoning. Group work improved students’ ways of thinking and ways of understanding. Students were comfortable when asking questions and for clarification about mathematical problems with friends as the need arose. Exploratory talk enabled students to justify their opinions, and this led to adaptive reasoning. One student captured the benefits of collaborative small groups when he stated that:
I find Tutorial sessions beneficial to me as we get to interact with other students and justify our answers. Problems were solved quicker. It’s more convenient and comfortable solving mathematical problems with friends. In tutorials we are free to ask further questions and clarifications as need arises.

(FG1: Sacky, Line 5)

The intervention programme implemented a slower pace of mathematics teaching. The majority of students found the content and pace of the basic Mathematics module to be ‘just right’. The module was designed with a moderate introduction period to build student confidence, morale and help alleviate some students’ phobias about Mathematics. Students enjoyed this because they had more time to focus on other mathematics modules and other subjects. One student concurred that the mathematics intervention promoted self-development by saying “Being on the intervention programme, I have gained self-confidence and all motivation needed to go through this programme. This gave me extra motivation to work harder than before. I hope this will work forever” (FG2: Keith, Line 48).

The slower pace of mathematics teaching reduced students’ anxiety about their mathematics learning. Students also appreciated the extra feedback. The lecturers could explain a wider variety of mathematical problems and had more time to answer questions. Students became more confident in their learning, believing that the results in their Mathematics tests, assignments and examinations were testament to the quality of the teaching. This gave them the confidence to believe that they could compete favourably with other students on the standard mode. They changed their perceptions of what they could actually achieve: their worries changed from whether they would pass assignments and tests, or qualify to sit exams, to how well they would perform.

Different teaching approaches were explored in the alternative mode and students had the flexibility of selecting lectures of their choice. The use of an interactive whiteboard enhanced lectures, making them more visual, understandable and interactive. It was found that showing a single Mathematics concept symbolically, numerically and visually could lead to improved disposition. Also, student interaction through the use of the interactive whiteboard was improved because the board offered space that allowed students to engage in active collaboration. Finally, lecturers could present material featuring large, vibrant images.
The applications to statistics, engineering and other science courses were found to be particularly useful in aiding understanding. Students could recognize and expand the importance of mathematics within statistics, engineering and other science courses and in this way gained an appreciation of the direct relevance of the topics studied. This helped to create enthusiasm and interest in solving mathematical problems.

Conclusion

It was found in this research that the mathematics intervention programme did indeed bridge the gap in the mathematics content taught, and this enabled students to build a strong foundation in university mathematics. In addition, the mathematics intervention programme reduced students’ anxiety about mathematics learning. Tools used in this intervention programme included an interactive whiteboard which provided strong visual representation that led to improved visualization, student engagement and agency. The small group sessions were seen as important and powerful for enabling learning. Students were open to working in collaborative small groups. Group work enhanced exploratory talk which in turn led to improving students’ adaptive reasoning. Finally, the team teaching strategy advanced the level of interaction between students and lecturers as well as between the students themselves.

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THEME 2

TEACHERS AND TEACHING
HOW DO TEACHERS CHARACTERISE THEIR TEACHING FOR CONCEPTUAL UNDERSTANDING AND PROCEDURAL FLUENCY?
A CASE STUDY OF TWO TEACHERS

DANIEL F. JUNIUS

This case study investigated and attempted to understand the Mathematics teaching practices of two proficient teachers who each claimed to have a specific approach to teaching Mathematics. One teacher claimed to be mainly procedural in her teaching, while the other claimed to teach mainly in a conceptual manner. The study revealed that each teacher was consistent in her claimed approach, but that each teacher’s practice came about as an evolutionary process over an extended period of time. The findings of this study suggest that peer support and sharing of practices has the potential to contribute positively to teachers’ classroom practices.

Introduction and background context
Everyone is unique and in mathematics teaching every teacher has a unique approach to teaching the subject matter to learners. The two Grade 10 teachers who formed the focus of the study each described their teaching style as focusing on either procedural or conceptual aspects. One teacher claimed to focus only on “methods and rules” when teaching Mathematics. In contrast, the other claimed that she uses every “teaching opportunity to teach for understanding”. When two very different approaches are followed, both yielding excellent results, it seems an ideal opportunity to carry out a case study of the manifestations of the claimed teaching approaches. This study attempted to do just that.
The notion of conceptual understanding and procedural fluency remains a key element of mathematical proficiency in terms of learning. However, while these strands are defined and conceptualised by Kilpatrick, Swafford and Findell (2001) as learner proficiencies, it is not clear what teaching characteristics teachers might adopt when teaching for these proficiencies. This study thus interrogated the two teachers’ understanding of a “conceptual” and “procedural” approach, and investigated how they applied these approaches in their Mathematics teaching practice.

Aims of the research
This study focused on gaining insight into two teachers’ different approaches to teaching Mathematics to Grade 10 learners. In particular, the goal of the study was to analyse and understand the teaching styles of two teachers who claimed that their Mathematics teaching was characterised by 1) a conceptual and 2) a procedural approach respectively.

Literature review
The debate about the learning of Mathematics has developed over many years with new terms appearing such as ‘meaningful learning’, ‘relational understanding’ and ‘instrumental understanding’. Shulman (1986) introduced ‘learning with understanding’ while Hiebert (1986) talked about ‘conceptual knowledge’ versus ‘procedural knowledge’. Research undertaken by the National Research Council in the United States (Kilpatrick, et al., 2001) culminated in the identification and characterisation of five strands of mathematical proficiency. Included within these five strands are the strands of ‘conceptual understanding’ and ‘procedural fluency’.

Kilpatrick, et al. (2001) see conceptual understanding as “an integrated and functional grasp of mathematical ideas” (p. 118). Hiebert (1986) defines conceptual knowledge as follows:

> Conceptual knowledge is characterized most clearly as knowledge that is rich in relationships. It can be thought of as a connected web of knowledge, a network in which the linking relationships are as prominent as the discrete pieces of information.

(pp. 3-4)
In a similar vein, Engelbrecht, Harding and Potgieter (2005) provide the following working definition of conceptual understanding:

Conceptual understanding consists of those relationships constructed internally and connected to already existing ideas. It involves the understanding of mathematical ideas and procedures and includes the knowledge of basic arithmetic facts. Students use conceptual understanding of Mathematics when they identify and apply principles, know and apply facts and definitions, and compare and contrast related concepts.

(p. 701)

Mathematics relies on many concepts or ideas that are often abstract and intertwined. To solve a problem a learner can either execute an algorithm according to a set of rules that the learner has memorized, or see the mathematical concept in its context and apply it with understanding and insight. The latter method enables learners to come up with new ideas of their own by connecting their ideas to what they already know. Conceptual understanding improves a learner’s ability to retain information. Once a concept has been grasped and applied, it becomes part of a learner’s knowledge base. By contrast, when a learner merely memorizes a method to apply to a certain problem, the method is easily forgotten. Conceptual understanding thus implies learning with understanding and helps the learner to make sense of the problem and apply knowledge effectively and appropriately. A learner with conceptual understanding is able to solve a problem because such a learner has assimilated and integrated an understanding of mathematical concepts.

In order to teach learners conceptually, teachers need to thoroughly understand the subject matter and also be flexible so they can help learners create useful cognitive maps, relate ideas to one another, and address misconceptions. Teachers need to see how ideas connect across fields as well as to everyday life. This kind of understanding provides a foundation for pedagogical content knowledge that enables teachers to make conceptual ideas accessible to others (Shulman, 1987).

Kilpatrick, et al. (2001) see procedural fluency as “knowledge of procedures, knowledge of when and how to use them appropriately, and skill in performing them flexibly, accurately, and efficiently” (p. 121). Rittle-Johnson and Alibali (1999) simply define it as “action sequences for solving problems” (p. 175). Hiebert (1986) characterises procedural
knowledge as comprising two distinct parts, one part the “formal language, or symbol representation system of Mathematics” and the other the “algorithms or rules for completing mathematical tasks” (p. 6). Thus, for Hiebert (1986), knowledge and recognition of the symbols and structures used in Mathematics are indicators of procedural knowledge. Engelbrecht, et al. (2005) define procedural fluency as “skill in carrying out procedures flexibly, accurately, efficiently, and appropriately” (p. 701) and thus see it as including, but not being limited to, algorithms.

In order to teach learners procedurally, teachers emphasise routine procedures and the development of algorithms. Some authors see procedural fluency in teaching as merely the mechanical execution of an algorithm to get a solution for a problem, while others describe it as having the knowledge and insight to arrive independently at a solution for a problem.

Conceptual knowledge and procedural knowledge lie on a continuum and cannot always be separated; however, the two ends of the continuum represent two different types of knowledge. It is likely that children’s conceptual understanding influences the procedures they use and vice versa. As Hiebert (1986) remarks:

Mathematical knowledge, in its fullest sense, includes significant, fundamental relationships between conceptual and procedural knowledge. Students are not fully competent in Mathematics if either kind of knowledge is deficient or if they both have been acquired but remain separate entities.

(p. 9)

In order to adopt a specific approach (conceptual or procedural) to teaching Mathematics, it is important that a teacher has both a deep conceptual and procedural understanding of Mathematics. It is expected that the teacher should process and present the subject matter to the learners in such a way that it will develop a high level of conceptual and procedural understanding in the learners in order to achieve mathematical competency. Competency cannot be achieved if either kind of knowledge is deficient or if they remain separate entities (Hiebert, 1986).
Methodology

This case study focused on the teaching practice of two successful teachers who developed their practice over a period of many years, each one with a unique approach to Mathematics teaching. One claimed to have a mainly procedural approach while the other a mainly conceptual approach. This study was carried out in order to gain insight into these different approaches to teaching Mathematics to Grade 10 learners, and is situated within the interpretive paradigm.

Qualitative data was collected by means of video recording lessons of each of the two participating teachers while covering the same learning material. To ascertain the ‘theories’ of their own teaching methods, these videos were analyzed collaboratively with each of the teachers, encouraging each one to comment and share their views on the unfolding of their lessons. A grid was designed to structure and assist in the identification of conceptual or procedural actions during each phase of the recorded lessons. This grid was completed by each teacher during the screening of their recorded lessons. This process allowed for a thorough understanding of each teacher’s personal understanding of their teaching approach. Additional qualitative data was then obtained through a series of interviews. In some cases direct questioning was used and in other cases a semi-structured approach was followed. Finally, informal open-ended discussions were held with the two teachers, mostly at their request.
Table 1: Lesson analysis grid.

<table>
<thead>
<tr>
<th>Procedurally Orientated Teaching</th>
<th>Conceptually Orientated Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teaching Practice</strong></td>
<td><strong>Teaching Practice</strong></td>
</tr>
<tr>
<td>1a. Explaining how to ...</td>
<td>1b. Ask “why”, asking why not?</td>
</tr>
<tr>
<td>[step-by-step algorithm]</td>
<td>[Why this step?]</td>
</tr>
<tr>
<td>2a. Teaching definitions and</td>
<td>2b. Explore possible definitions,</td>
</tr>
<tr>
<td>symbols</td>
<td>symbols</td>
</tr>
<tr>
<td>3a. Practice steps</td>
<td>3b. Design or discover own</td>
</tr>
<tr>
<td></td>
<td>steps</td>
</tr>
<tr>
<td>4a. Calculator: Teach steps to</td>
<td>4b. Solve a problem, try to use</td>
</tr>
<tr>
<td>perform an operation</td>
<td>the calculator</td>
</tr>
<tr>
<td>5a. Only one “right” way to</td>
<td>5b. Multiple strategies to solve</td>
</tr>
<tr>
<td>solve a problem. [the right</td>
<td>a problem. [process more</td>
</tr>
<tr>
<td>answer is everything]</td>
<td>important than the answer]</td>
</tr>
<tr>
<td>6a. Answer to a problem is</td>
<td>6b. Answers pose more</td>
</tr>
<tr>
<td>final</td>
<td>opportunities for learning</td>
</tr>
<tr>
<td>7a. Skill teaching is important.</td>
<td>7b. Connecting ideas and</td>
</tr>
<tr>
<td>Focus on a single skill to</td>
<td>concepts in Mathematics</td>
</tr>
<tr>
<td>arrive at an answer</td>
<td></td>
</tr>
<tr>
<td>8a. Answers in isolation</td>
<td>8b. Relate to the real world</td>
</tr>
<tr>
<td>9a. Word problems directly</td>
<td>9b. Posing a problem, develop</td>
</tr>
<tr>
<td>based on the required skill</td>
<td>skill through reasoning</td>
</tr>
<tr>
<td>10a. Algorithm is everything</td>
<td>10b. Algorithm seen as only one</td>
</tr>
<tr>
<td></td>
<td>form of approaching a solution</td>
</tr>
<tr>
<td>11a. Wrong answer is absolute</td>
<td>11b. Wrong answer provides</td>
</tr>
<tr>
<td></td>
<td>investigation opportunity into</td>
</tr>
<tr>
<td></td>
<td>understanding the problem</td>
</tr>
<tr>
<td>12a. Level one questioning,</td>
<td>12b. Questioning that requires</td>
</tr>
<tr>
<td>Typically expecting only an</td>
<td>adaptive reasoning, and the</td>
</tr>
<tr>
<td>answer on a question</td>
<td>consideration of alternatives</td>
</tr>
<tr>
<td>13a. Teacher demonstrates.</td>
<td>13b. Teacher facilitates.</td>
</tr>
<tr>
<td>Teacher-centred approach.</td>
<td>Learner-centered approach.</td>
</tr>
<tr>
<td>Instructive</td>
<td>Investigative.</td>
</tr>
</tbody>
</table>
Findings and discussion
Teacher A in the case study never studied mathematics at tertiary level but showed a keen interest in teaching Mathematics. She started teaching Mathematics at Grade 7 level and gained knowledge by studying the prescribed textbooks on her own. By teaching Mathematics for a few years at a Grade 7 level she gained the required content knowledge and confidence to teach more advanced grades, and eventually was able to teach Grade 12. “When I prepared for my lessons, I studied the content and memorized the steps to solve the example problems, then I taught it to my classes the next day”. Her perseverance and hard work proved to be fruitful over the years, and she is rewarded with excellent external results. Nobody ever spoke to her about any method of teaching Mathematics and as she explained later during the interviews, “I developed my own method of teaching Mathematics, which I call a method-based system. I teach the steps to the learners, they memorize it exactly as I wrote them down on the board and then they apply it”. The outstanding results of her Grade 10 learners during the external examinations affirmed and reinforced her beliefs in her own methodology. In terms of the definitions for teaching procedurally, and as showcased by her own recorded lessons, she approached every lesson in a characteristically procedural manner.

The second participant in the study, Teacher B, claimed that she teaches conceptually, or as she described her methodology: “I teach children to understand and not to study like parrots”. She also achieves consistently excellent results in the external examinations. She ascribes

<table>
<thead>
<tr>
<th>14a. Problems are only computational. Follow prescribed steps</th>
<th>14b. Problems open-ended</th>
</tr>
</thead>
<tbody>
<tr>
<td>15a. Focus on procedures only</td>
<td>15b. Focus on concepts to develop procedures</td>
</tr>
<tr>
<td>16a. Body language: In front of the class – one way communication. Questioning – only expect the right answers</td>
<td>16b. Body language: Move between learners, constantly prompting learners for responses and comments. Leading learners in reasoning</td>
</tr>
<tr>
<td>17a. Homework control: Mark work right or wrong</td>
<td>17b. Homework control: Discuss answers – right and wrong; Adds comments like ‘why?’ or ‘explain’</td>
</tr>
</tbody>
</table>
this to her ability to “reveal the workings of Mathematics to learners and to teach them to develop their own plans to solve problems”.

Both teachers completed their studies long before the notions of conceptual and procedural teaching were clearly defined to them. Nonetheless, it was clear that each teacher had adopted a particular teaching approach (what an informed outsider would refer to as teaching procedurally in the case of Teacher A and teaching conceptually in the case of Teacher B) developing specific teaching tools within their own paradigm.

During the course of the study, Teacher A progressively identified several factors that contributed to her adopting a procedural approach to teaching Mathematics. These included (i) time constraints related to a very full Mathematics syllabus, (ii) her limited formal training in the didactical aspects of teaching Mathematics, (iii) personal experience of weaker learners responding better to a more procedural approach, (iv) limited knowledge of or exposure to the philosophy of teaching, and (v) limited interaction with other teachers. Teacher A remarked that in her whole teaching career colleagues had never ever discussed any didactical issues with her – although teachers would discuss what they were going to do in upcoming lessons, they never discussed how they were going to do it.

During the course of the various interviews, Teacher A repeatedly remarked that she was “very much focussed on the methods”, describing the typical format that characterised her lessons as including (i) the division of the content into learnable facts, (ii) writing down the steps that learners must memorise to solve problems, (iii) the application of the rules, and (iv) engaging learners with repetitive exercises.

Although Teacher A regarded her teaching style as procedural, there was some evidence that it is interspersed with conceptual dimensions. For example, during the interview she remarked that “it is for me important that [the learner] can show the insight how he arrived at the answer”. This can be interpreted as a conceptual feature. On further probing, however, it became apparent that she regarded this insight largely in terms of the required steps that a learner is expected to follow to correctly reach a solution. She illustrated this by saying, “If you have the answer wrong – one can go back and then you should be able to show me the method. By doing so you can earn marks without having the answer right”.

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During probing, Teacher A admitted that she sometimes varies her approach when working with more talented learners. In her own words: “Yes, sometimes I will ask a learner to suggest how he will solve a problem. I will allow the learner to guide me through the problem while I write the solution down”. This is consistent with a more conceptual approach to the understanding of Mathematics. Interestingly, it emerged during the interviews with both teachers that they believed that weaker learners are likely to gain more through procedural teaching rather than a conceptual approach. Teacher B even remarked that weaker learners often preferred to be taught in a procedural way: “You know, I think some slower learners prefer to have a recipe written down for them, maybe it makes them feel safe if they have something that they can study”.

Substantiating Teacher B’s claim of being purely conceptual in her approach proved to be more difficult than anticipated. She defined conceptual teaching more as a skill to lead learners to an in-depth understanding of mathematical subject matter as well as an ability to transform learners into adaptive thinkers. In her own words, she described her teaching as “always having a magic plan for every new concept or idea I have to teach. I would like to describe my ‘teaching practice’, as you call it, as ‘teaching with a plan’ so that learners can understand the work, rather than being able to [simply] do the sums”.

During the various interviews Teacher B often used the phrase “they should understand”. When probed to elaborate on the term ‘understanding’, she explained that the learners should “click”, “that the lights should go on for them” or that they should experience a moment where they can confidently tackle any problem based on the concept covered. This illustrates a strong conceptual approach to teaching.

Although Teacher B regarded her teaching style as conceptual, there was some evidence that there were also procedural dimensions. For example, she made some challenging remarks by saying that it is extremely important that the learners should know the theory and that they should memorize it. Initially this was regarded as being inconsistent with a conceptual approach, but in context this was seen as being part and parcel of teaching for understanding. Mathematics is grounded in many rules and axioms that learners simply need to know and memorise. She placed this view in context as follows: “Take for example circle geometry. I will let them measure the angles in a few semi-circles and they will discover that the angle in a semi-circle is always a right angle. When they
start to solve problems where they have to supply reasons for an answer, they just cannot remember that the angle in a semi-circle is 90°. After we are done with all these rules I will type them out for them, each one with a picture and then they must memorize them”.

An interesting challenge highlighted by Teacher B is the amount of creativity it takes for a teacher to remain conceptual when teaching Mathematics: “You must know that it was never easy to just teach for understanding and to use techniques to stimulate the learners to think about problems”. Teacher B also claimed that it is very difficult for one to sustain the momentum to constantly teach conceptually. Although a learner-centred approach requires that a learner should be allowed to learn at his or her own pace, it is at times not feasible to sustain the same level of motivation and interest if the learners are at different stages of mastering the learning material. Despite the intentions of a learner-centred policy, the Namibian Education System, in my view, still endorses a teacher-centred philosophy as it places so much emphasis on the results of external examinations. This has significant implications on a teacher with a predominantly conceptual approach, particularly when she prepares learners for an external examination.

**Conclusion**

Irrespective of the approach that a teacher adopts for teaching, the diverse cognitive levels amongst learners in the class affects how one teaches. It is simply not possible to have a homogeneous group of learners (all learners on the same cognitive level) within the same class group. As it emerged in the data analysis, both teachers raised the point that it remains a challenge for a motivated teacher to accommodate these different levels of mathematical ability in one class. This is particularly apparent when one group in the class is talented, diligent and motivated, while another group reveals just the opposite attitude. In the words of Teacher B “It is an art to teach Mathematics. Learners can very easily say that you are unable to explain the work to them. This happens especially when I try to allow them to arrive on their own at a wonderful mathematical truth. On the other hand you will get learners, the bright ones, of course, who want to be challenged. They get motivated when they are confronted with a challenging problem to solve”.

This study was significant in that it brought about a heightened awareness in both participating teachers. The process also motivated both participants, and their discussions with other Mathematics teachers have
sparked meaningful debate amongst teachers in their school. Both teachers also highlighted the need for a professional teachers’ forum in which to share experiences with colleagues and other teachers.

The debate about procedural and conceptual understanding and procedural and conceptual instructional approaches is an important one. This case study provides a window into the issue, and underlines once again the complexity of the search for understanding the learning of Mathematics.

REFERENCES


STUDENT TEACHERS’ EXPERIENCES IN USING MULTIPLE REPRESENTATIONS IN THE TEACHING OF GRADE 6 PROPORTION WORD PROBLEMS: A NAMIBIAN CASE STUDY

Bosman Simasiku

This case study explored the experiences of four student teachers in using a multiple representational approach to the teaching of Grade 6 proportion word problems. The findings of this study suggest that a multiple representational approach to proportion word problems represents conceptually meaningful classroom pedagogy, particularly when different representations are used in conjunction with one another. It is recommended that in-service workshops for teachers and student teachers on the integration of multiple representational approaches to the teaching of Grade 6 proportion word problems should be initiated.

Introduction and background context

There are two key factors that prompted this research to be conducted. Firstly, at the teacher education institution where I teach Mathematics Education, student teachers comment countless times that word problems are difficult to teach to upper primary learners. Secondly, the SACMEQ III report indicates that Namibian Grade 6 learners struggle with word problems (Hungi, et al., 2010). The results from SACMEQ III, along with student teachers’ perceptions of teaching word problems, motivated me to look deeper into this issue by carrying out research with student teachers, specifically focusing on gaining insights into the teaching of proportion word problems at a Grade 6 level.
Word problems are an integral component of any mathematics curriculum, and proficiency in solving word problems should therefore be central to any learning and teaching programme. In Namibia, word problems and problem solving have been incorporated as integral parts of the Grade 6 Mathematics curriculum (Namibia. Ministry of Basic Education, 2006). This is consistent with the suggestion made by Simons (1993) that “problem solving should be an accepted integral part of any mathematics programme” (p. 5).

There are many different approaches to solving proportional word problems – for example the cross-product algorithm, the between-comparison and within-comparison methods, making use of a table or graph, or utilising diagrams or models. An essential skill required for being able to use such a variety of approaches is the ability to translate and integrate “verbal, graphic or tabular information into an arithmetic form” (Hungi et al., 2010, p. 5) and vice versa. This skill is central to the solving of word problems as it involves the translation of verbal and written information into a mathematical language that enables mathematical manipulation and operations.

Despite the many approaches to solving proportional word problems, most upper primary in-service teachers and student teachers seem to use the cross-product algorithm for teaching Grade 6 proportion word problems. The example below illustrates the typical cross-product methodology in solving a proportion word problem:

\[
\begin{array}{c|c|c}
\text{No. of bricks} & \text{Height} \\
1 & 8 \times \text{X} \\
5 & \text{X} \\
\end{array}
\]

Cross-product algorithm: \(X \times 1 = 5 \times 8\)
\[
\therefore X = 40 \text{ cm}
\]

Although the cross-product approach represents a quick route to getting to the answer, the basic steps of this process can be followed with very little conceptual understanding of proportionality. The use of only a single method to teach proportion word problems is problematic since, as Cramer and Post (1993) assert, the use of multiple representations in
teaching proportion word problems would support more meaningful and deeper learning in solving these problems. Furthermore, Kennedy, Johnson and Tipps (2008) advise that “the cross-product algorithm should not be introduced until students have fully developed and refined their understanding that proportional relationships involve multiplicative relationships” (p. 334). Although they do not discard the use of the cross-product algorithm entirely, they do suggest that it is only one of the multiple ways to solve proportion word problems. Thus, although the use of the cross-product method is useful, it also has the potential to lead to the uncritical memorisation of rules and thus to a superficial understanding of proportionality. The purpose of this research is thus to explore how a multiple representational approach could enhance the teaching of proportional word problems, thereby viewing mathematics as a “sense-making pursuit” (Brown, Collins & Duguid, 1989, p. 15).

Aims of the research

The purpose of this study was to explore the experiences of four participating student teachers in using multiple representational approaches to teaching Grade 6 proportion word problems. These different approaches included the cross-product algorithm, the between-comparison and within-comparison methods, making use of tables or graphs, and utilising diagrams or models.

Literature review

There are many methods and strategies that promote conceptual understanding of proportionality that can successfully be used to teach Grade 6 proportion word problems:

The cross-product method

In the cross-product method the missing term of the proportion is found by using a cross-multiplication algorithm as previously described. The method involves using a variable to represent the missing value, setting up an equation using the cross-multiplication algorithm, and solving the equation to determine the missing value.

The between-comparison method

In this method the missing term of a proportion is found by making “a comparison between ratios of the proportion” (Nielsen, 1998, p. 38). Van de Walle, Karp and Bay-Williams (2010, p. 364) explained that this
method makes use of a “ratio of two corresponding measures in different situations”. By way of example, consider the following proportion question: \( \frac{2}{3} = \frac{8}{X} \). In the between-comparison method learners need to find a multiplicative relationship between 2 and 8 (the two numerators in this case). Since the multiplicative relationship is 4, the missing term of the proportion statement can be determined by multiplying 3 by 4 to arrive at \( X = 12 \). At the level of Grade 6, this method can be used where quantities in different situations are compared.

**The within-comparison method**

In this method the missing term of a proportion is found by making a “comparison within the ratios” of the proportion (Nielsen, 1998, p. 38). Van de Walle, et al. (2010, p. 363) explain that this method makes use of a “ratio of two measures in the same setting”. By way of example, consider the following proportion question: \( \frac{2}{3} = \frac{8}{X} \). In the within-comparison method learners need to find a multiplicative relationship between 2 and 3. Since the multiplicative relationship is 1.5, the missing term of the proportion statement can be determined by multiplying 8 by 1.5 to arrive at \( X = 12 \). At the level of Grade 6, this method can be used where quantities in different situations are compared.

**The table method**

In this method the missing term of a proportion is found by creating a table and using it to explore the concept of proportion. Van Etten and Adendorff (2010) and Van de Walle, et al. (2010) refer to this table as a “ratio table” which represents a way of organizing information to show how two variable quantities are related.

<table>
<thead>
<tr>
<th>Acres</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pine trees</td>
<td>75</td>
<td>150</td>
<td>225</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cramer and Post (1993) emphasize the importance of the table strategy by commenting that “constructing a table helps to identify the numerical relationship between the two quantities” (p. 345). The value of the table thus lies in developing functional thinking by focusing on the relationship between varying quantities, either across rows or down columns. Tables can thus be used to support the within-comparison and between-comparison methods.
The diagrammatic method
In this method the missing term of a proportion is found by using diagrams that explore the concept of proportion. According to the Pacific Institute for Mathematical Sciences (2009, unpaged) this method is a “pictorial representation of known and unknown quantities and their relationships in a problem”. Van de Walle, et al. (2010, p. 27) refer to it as a method that uses pictures or drawings that represent the concept or “onto which the relationship for that concept can be imposed”.

The graphical method
In this method the missing term of a proportion is found by creating a graph to locate the missing term. Van de Walle, et al. (2010, p. 359) state that “graphs provide another way of thinking about proportions, and they connect to algebraic interpretations”. All graphs that represent direct proportional scenarios can be graphed as straight lines passing through the origin, the slope of the line being the ratio of the y-coordinate to the x-coordinate of a given point.

The oral informal method
In this method the missing term of the proportion is found by means of trial-and-error. Koedinger and Nathan (2004) refer to this method as the ‘guess and test’ strategy.

Methodology
The study is located in the interpretive paradigm and made use of a case study approach. The research was conducted at one of the campuses of the University of Namibia and in two selected upper primary schools in the surrounding area. The participants in the study were four third-year
BETD student teachers selected on a voluntary basis from a pool of students specializing in teaching upper primary Mathematics. Three of these student teachers were male and one was female. Each of the four selected student teachers was allocated to a Grade 6 class in two different primary schools.

There were five phases to the research process. The first phase took the form of a workshop. During this workshop the four participating student teachers were introduced to multiple representational approaches that could be used to teach Grade 6 proportion word problems. The workshop also focused on how to craft, use and adapt multiple representational activities in the classroom. The participants were then tasked with designing and preparing lessons making use of multiple representational approaches to teaching proportional word problems. In the second phase the participating student teachers trialled their lessons during their period of teaching practice. The third phase took the form of another workshop in which participants were able to reflect on their teaching experience, discuss challenges with their colleagues, and adjust and develop the content of their lessons. In the fourth phase the student teachers implemented their lessons to their designated Grade 6 classes. These lessons were video-recorded. The final phase took the form of a focus-group interview where the participants could reflect on their experiences, the major focus being on the participating student teachers’ subjective experiences of using multiple representations in the teaching of proportion word problems.

Findings and discussion

The between-comparison method

The four participating student teachers found the between-comparison method to be generally effective in the teaching of Grade 6 proportion word problems despite the challenges encountered. Some of the challenges included difficulties with the English language, different and individual abilities of the learners, and lack of proficiency in the learners’ multiplication and division skills. Notwithstanding these challenges, not only does the between-comparison method serve as a good platform to understanding the concept of proportion, it also serves as a meaningful approach to exploring and reasoning about multiplicative relationships thereby potentially facilitating deep understanding of proportional reasoning.
The within-comparison method
The participating student teachers found the within-comparison method to be generally effective despite the challenges encountered. Similar to the between-comparison method this approach not only facilitated a meaningful representative approach but also encouraged the exploration of the multiplicative relationship of proportion.

The diagrammatic method
The participating student teachers found the diagrammatic method to be generally effective despite the challenges encountered. The visual dimension of this approach was found to be particularly useful in the exploration of proportions. The visual emphasis aligns well with the Grade 6 learners’ stage of development. This approach works well with any of the other multiple representational approaches in this study.

The table method
The participating student teachers also saw the table method as generally effective. It was found to work particularly well when used in conjunction with the between-comparison method, the within-comparison method and the graphical method.

The graphical method
The participating student teachers saw the graphical method as being generally difficult to use in the teaching of Grade 6 proportion word problems. Since plotting of graphs is not in the Grade 6 curriculum, the learners found it difficult to draw the required graphs. Despite this, they found the interpretation of graphs very meaningful especially when used in conjunction with the table method.

The cross-product method
The four participating student teachers were not unanimous in their experiences of the effectiveness of the cross-product method. Some found that this method worked well, while others did not. It was noted that this method requires a deep conceptual understanding of proportion. This method works well when used in conjunction with the within-comparison method and the between-comparison method.
The oral informal method

The participating student teachers found the oral informal method to be generally effective despite the challenges encountered. The notion of trial-and-error can be a very powerful approach in exploring proportions. It encourages learners to invent their own ways of doing mental calculations. It also works well in conjunction with the other representational approaches in this study.

This study found that the meaningful use of these multiple representational approaches also depended on other factors such as: (a) avoiding the use of only one representational approach, i.e. using them in conjunction with one other, (b) using appropriate problem solving strategies, (c) using simple but appropriately contextualized proportion word problems that are familiar to the Grade 6 learners’ real life situations, (d) using the relevant prior knowledge that Grade 6 learners bring to the classroom, (e) fluency in multiplication and division skills, (f) using co-operative learning, (g) encouraging and affirming the learners, (h) an ability to understand the language, (i) the use of relevant metaphors, and (j) the ability to address the challenges that were presented when using a given method.

Based on the study, in order to introduce a multiple representational approach in the teaching of Grade 6 proportion word problems, the following recommendations are suggested:

- Student teachers should be trained in the use of multiple representations;
- The curriculum should encourage a multiple representational approach to teaching proportion;
- In-service workshops should be run to train teachers in these approaches;
- Microteaching and teaching practice on the effective integration of multiple representational approaches in the teaching of proportion word problems should be encouraged;
- Textbooks should reflect multiple representations when dealing with proportion; and
- Further research needs to be conducted into this pedagogical approach.
Conclusion

The use of multiple representations, and the multi-dimensional approach that underpins it, provides different slants from which to explore and engage with the notion of proportion. The findings of this study show that a multiple representational approach to proportion word problems has the potential to facilitate a conceptually meaningful teaching and learning experience. Despite a number of challenges encountered by the participating student teachers – such as learners’ difficulties with the English language, the different and individual abilities of the learners, and a lack of proficiency in learners’ multiplication and division skills – the multiple representational approach to teaching proportion word problems in Grade 6 was generally effective. Furthermore, an important aspect of this study was that it generated an awareness of multiple representations and that multiple representational approaches can play an important role in the teaching of Grade 6 proportion word problems.

REFERENCES


This chapter reports on a qualitative case study which examined and analysed the experiences of selected mathematics teachers when using the van Hiele phases of instruction in designing and implementing a Grade 11 circle geometry teaching programme. The three purposefully selected participants were Grade 11 Mathematics teachers. Data for this research was collected using a variety of techniques such as the interviews, classroom observations and document analysis. The findings of this research make four claims with regard to the experiences of the participants using van Hiele’s phases of instruction. Firstly, all three participating Mathematics teachers used and implemented all the five van Hiele phases of instruction in their lessons. Secondly, the teachers navigated quite freely from one phase of instruction to the next, but also returned to earlier phases for clarification and reinforcement of concepts taught. Thirdly, the teachers saw the phases of instruction as a good pedagogical tool or template for planning and presenting lessons. Fourthly, the majority of the learners followed the instructions and seemed to obtain the answers faster than expected.

Introduction

This chapter reviews and consolidates the findings of a study conducted with the aim of investigating selected Mathematics teachers’ experiences of designing and implemented a Grade 11 circle geometry teaching
programme using the van Hiele phases of instruction as a conceptual framework. The Mathematics teachers’ approach to geometric instruction determines, to a large extent, the mathematical thinking strategies and dispositions that our learners develop and attain. In my experience as a mathematics teacher, I have observed how a number of high school learners struggle or sometimes fail to recognize geometric shapes, make accurate constructions, accurately describe properties of plane geometry figures, and construct appropriate proofs in geometry. I note with frustration how these learners often reach a dead end when it comes to solving geometrical problems. This, in my view, leads to a negative perception of geometry as a worthwhile mathematical activity. This affects learners negatively, even those who are mathematically oriented. In conversation with a Computer Studies specialist (a Peace Corps volunteer) who helped out with one Grade 8 Mathematics class during his time at my school, I asked him how he felt about geometry in general. He responded: “I hate geometry! I am an Algebra guru.” This epitomises the feelings of many teachers about geometry. This teacher has a sound knowledge of formal geometry but ‘hates’ geometry “because it is too complicated or rather people like to complicate it instead of just calling a spade a spade” (Personal communication, Q. Lee, July 12, 2012). The question I ask: Is geometry really that complicated or are there other factors that contribute towards this negative perception of geometry?

In conversation with mathematics teachers in Namibia, they identified numerous factors that they believe contribute towards their students’ poor performance and failure in geometry. These constraining factors include an inappropriate curriculum, weak textbooks, lack of teaching/learning aids and unmotivated students. van Hiele’s (1986) solution to overcoming these problems is for teachers to take responsibility for their own teaching and to make appropriate choices in their curriculum and lesson design. For example, if the curriculum is not suitable for your learners, design your own, and if the textbook is inappropriate for teaching and learning in your classroom, restructure it to suit your environment.

It is the assumption of this study that although learners experience difficulties with geometric conceptualization and reasoning, geometric thinking does not lie solely within their own learning ability or motivation. The teacher’s instructions and choice of exercises also play an integral role in the pupils’ learning. The renowned Dutch mathematics educator and researcher Van Hiele (1986) suggested that there are difficult moments that face every high school teacher in teaching
geometry. He too encountered many such moments where pupils failed to understand his teaching. According to van Hiele (1986, p. 45), “learning mathematics meant learning to think, and to be able to think precisely you should have attained the highest possible level”. How then can Mathematics teachers ensure that their pupils attain the highest possible level if the teachers themselves are not certain about what levels the pupils have achieved? I was particularly inspired by the van Hiele (1959, 1986, 1999) theory that sought to provide answers to the teaching and learning of geometry in high schools. Specifically I wanted to research the teaching aspect of the van Hiele theory and use the van Hiele phases of geometric instruction to design and implement a geometry module at the Grade 11 level.

**Aims of the research**

The main goal of my research was to design, implement and reflect on a ‘circle geometry teaching programme’ based on the van Hiele phases of instruction. The fundamental research question of this study was: What are the experiences of selected mathematics teachers when using the van Hiele phases of instruction in designing and implementing a Grade 11 circle geometry teaching programme?

**Literature review**

*“There is no king road to geometry”*

This was the answer that Euclid gave to the king of Egypt when he asked him to explain his book ‘Elements’ in an easier way. This is a profound illustration that the difficulty in understanding geometry is not an unusual phenomenon – it has existed since the ancient times. Nikoloudakis (2009) observes that similar research on the understanding of geometric concepts by learners has shown that learners in general find defining and recognizing geometric shapes and the use of deductive thinking in geometry problematic (p. 17). Burger and Shaughnessy (1986) echo this sentiment in their study where a number of secondary school learners interviewed in their clinical study had incomplete notions of basic shapes and their properties. “This observation might explain some of the frustrations students and teachers have with secondary school geometry courses. Students are not sufficiently grounded in basic geometry concepts and relation to ‘reinvent’ Euclidean geometry. Memorization may be their only recourse” (p. 46).
Many other researchers have also reported on learners’ geometry related difficulties in their various research projects. Weber (as cited in Nikoloudakis, 2009) for example, found that learners find it very difficult to successfully write simple geometry proofs. Senk (1989) on the other hand stated that many secondary school learners in the United States were not prepared for geometry classes. Fuys, Geddes and Tischler (1988) found that there was too much emphasis placed on formal symbolism and identification in the elementary school geometry curriculum, while relational understanding was underestimated. Research done in Southern Africa revealed similar problems when it came to assessing why learners struggle with formal geometry.

De Villiers and Njisane’s (1987, as cited in de Villiers, 1996, p. 12) study revealed that about 45% of learners in Grade 12 (Std 10) in KwaZulu Natal had only mastered Level 2 or lower, whereas the examination assumed mastery at Level 3 and beyond. De Villiers (1996) further attributes the failure of geometry in many secondary schools to the role of language that creates communication gaps between the teacher and the learners. Atebe and Schäfer (2010) in their study showed that participating secondary school learners “had a limited and arguably inadequate knowledge of basic geometric terminology…” (p. 63). This is also attributed to the traditional curriculum which is typically presented at a higher level than that of the learners (van Hiele, 1986).

As in South Africa, Namibia has a geometry curriculum that is heavily loaded in secondary school with formal geometry (de Villiers, 2010). I often feel frustrated when teaching the lower secondary learners by the lack of geometry knowledge and experience many of them bring from the primary school. In my view, learners in the primary schools do not spend enough time dealing with geometric ideas in a conceptual manner – their geometric understanding is often shallow and lacks conceptual understanding. Research revealed that difficulties with geometric conceptualization are often a result of various factors. Learners’ apparent inability to reason at a higher level of geometric thinking does not only lie within their own learning patterns or motivation. The teacher’s instructions and choice of exercises also play an integral and important role in the learners’ learning. Burger and Shaughnessy (1986) explained that high school geometry as it is taught in most high schools is taught at a deductive level while most learners are only capable of reasoning informally about geometric concepts upon entrance into geometry. De Villiers (2010) echoes this sentiment and states that within the South
African context the main reason for the failure of the traditional geometry curriculum is because its expectations are set at a higher level than that of the learners’ ability. For example, the curriculum might require the learners to reason at van Hiele level three of geometric understanding while the learners are only able to reason up to the second van Hiele level. Despite many curriculum reforms over the decades the geometry curriculum remains inaccessible to many learners. This study emphasised the central role that teachers play in rolling out any curriculum by taking ownership of their own planning. Teachers should develop geometric concepts sequentially in such a way that learners are able to work from less abstract notions to more complex concepts. This involves a carefully planned sequence of teaching events that develops geometric conceptualisation. The van Hiele theory provides a model to do just that.

This study was designed specifically to look for possible ways of teaching geometry so that it facilitates the attainment of higher van Hiele levels. The teaching intervention that is the central part of this study is intended to inspire and encourage teachers to design their own curriculum in such a way that it enables learners to develop meaningful geometric thinking. If learning geometry means learning to think and being able to attain the ‘highest possible level’ of conceptualization (van Hiele, 1986) then all mathematics teachers should be well versed in the nature of good geometry teaching.

The van Hiele theory

The van Hiele theory is a “learning model that describes the geometric thinking students should go through as they move from a holistic perception of geometric shapes to a refined understanding of geometric proof” (Genz, 2006, p. 4). This theoretical model was developed by the renowned educators, Pierre Marie van Hiele and his wife Dina van Hiele-Geldof about six decades ago. The model proposes five hierarchical levels of thinking that learners sequence through in order for them to master geometric concepts. These thinking levels are recognition, analysis, ordering, deduction and rigor. According to the van Hiele theory, “students move sequentially from one level of thinking to the next [level] as their capability increased” (van Hiele, as cited in Gutierrez, Jaime & Fortuny, 1991, p. 237).

Parallel to the development of the five level framework, van Hiele also developed a framework of teaching phases that supported teachers to move their learners from one level to the next. Van Hiele-Geldof (1958,
as cited in Fuys, et al., 1984) stressed that learners cannot progress through the levels of thinking without proper instruction. Hence, it is important that the teachers’ instruction is pegged at the appropriate van Hiele level to enable learners to attain the highest possible level in their learning environments.

The van Hiele phases of instruction

Van Hiele (1986) recommends a set of instructional phases that teachers should follow in order to facilitate the students’ movement between the van Hiele levels of geometric thinking. The phases of instruction are: information, guided orientation, explicitation, free orientation and integration. Teachers are advised to guide their learners’ geometric conceptualization by employing these five phases of instruction in their practices (van Hiele, as cited in Fuys, et al., 1984, Mistretta, 2000; Clements & Battista, 1992; Ding & Jones, 2007, Serow, 2008). A description of each phase of instruction is summarized in Table 1 below.

Table 1: summary of the descriptions of the van Hiele Phases of Instruction

<table>
<thead>
<tr>
<th>Phases</th>
<th>Description of phase focus; some illustrative examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>Teacher familiarizes the learners with content to be learned by engaging them in a content-based discussion.</td>
</tr>
<tr>
<td></td>
<td>Teacher learns and tests their pre-knowledge of the subject content and how they interpret the language. The learner gets acquaintance with the working domain; uses materials presented to him/her; examines examples and non-examples.</td>
</tr>
<tr>
<td>Directed Orientation</td>
<td>The teacher guides learners to uncover the connection and to identify the focus of the subject matter.</td>
</tr>
<tr>
<td></td>
<td>Learners engage with the concepts in order to begin to develop understandings of them and the connections between them.</td>
</tr>
<tr>
<td></td>
<td>Learners’ own language is still acceptable at this stage though the teacher’s role is to correct their language into a more accepted technical language.</td>
</tr>
</tbody>
</table>
By the completion of the integration phase, learners have reached a new level of thinking. This new level of thinking replaces the previous level of thinking and learners are once again ready to repeat the five phases of instruction at the next level of the van Hiele model of thinking. The cycle keeps on repeating until learners attain the highest possible level of geometric thinking for the content under study.

**Research methodology**

This qualitative case study was conducted within the interpretive paradigm. The sample consisted of three purposefully selected secondary school mathematics teachers in the Oshikoto region. Focus group
interviews, classroom observations and semi-structured interviews were the main instruments of data collection. The participating teachers engaged in a series of workshop activities where they were oriented into the van Hiele phases of instruction. They then designed a Grade 11 teaching programme that was explicitly framed by the five phases of instruction. During the three week implementation of the programme the teachers’ lessons were video recorded and the teachers were interviewed, both individually and in a focus group. The teaching programme design was inspired by a UK study of geometry teaching (Royal Society, as cited in Ding & Jones, 2007) which emphasised that “the most significant contributions to improvements in geometry teaching will be generated by the development of good models of pedagogy, supported by carefully designed activities and resources (p. 45).” Hence, instructions planned to nurture development from one level to the next level of thinking should include a sequence of activities, “beginning with an exploratory phase, gradually building concepts and related language, and culminating in summary activities that help students integrate what they have learned into what they already know” (van Hiele, 1999, p. 311).

Findings
The data analysed for this study revealed four central claims:

Claim 1: All three participating teachers used and implemented all the five van Hiele phases of instruction in their lessons that I observed.

The circle geometry teaching programme that the teachers finally committed to teaching either fitted exactly or aligned well with their own teaching and activity plans. All three teachers meticulously went through all five van Hiele phases of instruction during their lessons. For example, as per van Hiele’s framework, during the information phase, the teachers informed the learners about the content to be taught and established the learners’ existing knowledge. Teacher A informed the learners that they were going to learn about circle geometry and wrote ‘Circle Geometry’ on the chalkboard. She then asked them about circle geometry concepts and asked them to construct a circle and draw and label as many circle geometry concepts as they could possibly remember in order to test their prior knowledge.

During the directed orientation phase, Teacher B, for example continued building on the learners’ pre-knowledge by extending their engagement and instructing them to “construct a circle centre O,
diameter $AB$. Draw two chords from each $A$ and $B$ and let them intersect at a certain point $C$ on the circumference of the circle”. The teacher’s aim at this point was to see how the learners applied the concepts learnt in the information phase to construct the required circle.

During the explicitation phase, Teacher C engaged the learners in an elaborate discussion about the diameter of the circle. To test their understanding and further use of geometric language, the teacher gave the learners an activity using examples and non-examples of a diameter of the circle. During the free orientation phase, Teacher A, for example, provided structured activities for the learners to complete independently while assessing their progress.

During the integration phase, Teacher A asked her learners to explain verbally the angle properties of a circle. Teacher B asked his learners to write and construct a summary of the definitions of the parts of the circle and on the angle properties learnt. Teacher C, on the other hand, drew a circle on the chalkboard and asked the learners one by one to come up to the board and draw the circle geometry concepts that they had learned. In the interview with the teachers, I asked whether they were always aware of the phases that they were using:

Interviewer: Did you at all notice if you used the van Hiele phases during your lesson?

Teacher C: … Not really that I noticed much because I don’t really … but I think I have because I started from the beginning. Like you’re telling them what the topic is all about and what to do and then you’re letting them to apply what you’ve told them onto the chalkboard to show their working.

Teacher C acknowledged that she was not sure whether she could recall the technical definitions of the phases, but that she implicitly followed the logic of the framework. Teacher A also acknowledged that she did not really understand the technicalities of the phases, but that the framework helped her to teach the lessons thoroughly. Teacher B, on the other hand, kept on reminding me that it was I who introduced him to the van Hiele phases of instruction and he only did at each phase what I instructed him to do. I was interested in whether the participating teachers really implemented the phases of instruction as per the van Hiele theory, or whether they adapted the framework to suit their purposes. When I asked the teachers if they used the phases of instruction as the framework
suggested, they said that they did, but did not mention the particular phases per se. They rather sequenced what they did first, second, third, etc. When I analyzed this sequence, I found out that it was very similar to the five van Hiele phases of instruction (Fig. 1).

**Figure 1: Classification of the teachers’ understanding of the van Hiele phases of instruction.**

First - Information Phase  
(The teachers informed the learners about the topic to be learned).

Second - Directed Orientation Phase  
(The teachers instructed the learners to complete activities under teacher observation).

Third - Explication Phase  
(The teachers explained concepts to the learners and encouraged the use of correct geometric language).

Fourth - Free Orientation Phase  
(The teachers provided activities for the learners to complete independently).

Fifth - Integration Phase  
(The teachers asked the learners to summarise the content learnt).

**Claim 2: The teachers navigated quite freely from one phase of instruction to the next, but also returned to earlier phases.**

During the classroom observations, I noticed that the teachers moved backwards and forwards between the phases of instruction and yet could still stay on track with the programme. For example, when operating in the free orientation phase, the teachers would refer back to earlier phases of information such as the directed orientation phase, and sometimes even to the explicitation phase to clarify missing/unclear concepts. They would then go back to the free orientation phase and continue with what they were doing.

A typical example is from Teacher B’s first lesson when he asked the learners to construct a circle which should be a set of points that were 5 cm from a fixed point. When the teacher noticed how puzzled his learners looked, he decided to define the circumference of the circle (explicitation phase) as a set of points which are a fixed distance (pointed at a radius) from a fixed point (centre of the circle). The teacher explained the concept while providing sufficient information to supplement his
explanation. He then proceeded with his initial instruction when he noticed that the learners were coping.

Claim 3: The phases of instruction are seen by the teachers as a good pedagogical tool or template for planning and presenting lessons. The circle geometry teaching programme in this study lends itself well to sequencing activities according to the van Hiele phases of instruction. The programme enabled the teachers to align their planning of lessons and activities and their teaching of the five phases of instruction. Towards the end of the introductory workshop, Teacher A expressed that this was a good teaching programme which might work with other sections as well. She suggested that we could also use the teaching programme to plan lessons on Graphs and Functions in which our learners also experience difficulties. “These phases of instruction can also be used in Graphs and Functions and also Transformations chapters where most of our learners also have difficulties”. Teacher C commented that she could use the phases of instruction across the curriculum. “I think I can also use these phases in Life Science”.

Teacher B said that this way of planning was efficient for his practice. He was excited about this design as he said that there was no need for him to take the design along to his lesson presentation. He said that he read the van Hiele document several times and was ready to teach. “That paper is very clear so, I don’t think I need to take it along to class. I read it many times and everything is clear enough for me to teach without it”.

I noticed during the classroom observations that the teachers were very confident about their own practices. Various comments during the reflective interviews highlighted how effective this teaching programme had been for them. For example, when I asked Teacher A how she felt about the teaching programme during the free orientation phase, she stated, “I feel that this teaching programme can do some good to every mathematics teacher especially the teachers who are teaching for the first time. It really helped me to plan my lessons and activities even though I kept calling you to guide me”.

Even Teacher C who was very nervous at the beginning of her first lesson, revealed how effective the teaching programme had been for her own pedagogical practices. “Have you noticed that these learners only need a little push and then their thinking is already in order? ... I cannot believe I was so nervous about something so interesting like this teaching programme”.

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Claim 4: The majority of the learners followed instructions and seem to obtain the answers faster than expected.
In general it is expected that good practice enhances competent outcomes. All the teachers claimed that they did their part, and the learners performed very well during the assessment activities – often faster than they expected. In addition to the overall learner involvement, the learners remained on-task for the entirety of the learning time and throughout each activity. They conversed at length with each other and the teachers as they progressed from informal to formal language usage and reasoning.

Conclusion
This study was conducted with the aim of investigating Mathematics teachers’ experiences with designing and implementing a circle geometry teaching programme using the van Hiele phases of instruction as a conceptual framework. The findings of this research revealed that firstly, all the van Hiele phases were manifested in the circle geometry teaching programme and all three participating teachers used and implemented all five van Hiele phases of instruction in their observed lessons. Secondly, the teachers navigated quite freely from one phase of instruction to the next, but also returned to earlier phases for emphasis and consolidation. Thirdly, the phases of instruction are seen by teachers as a good pedagogical tool or template for planning and presenting lessons. Lastly, the majority of the learners participated well in the programme and obtained the correct answers more rapidly than expected.

REFERENCES


This paper presents a report of a study of the teaching of fractions by five level 5-7 student teachers during their teaching practice. The research investigated the experiences of the student teachers with regard to their practice of fraction teaching; their experience of the mathematics education course with respect to the teaching of fractions; and their prior experience related to fractions and fraction teaching at Grade 6 level. It was found that in many areas, students’ prior knowledge conflicted with the approaches to teaching introduced in the education course and this had an adverse effect on their practice of fraction teaching.

Introduction

One of the major challenges in teacher training programmes, specifically in mathematics education programmes, lies with the student teachers’ difficulties in dealing with various topics in mathematics, particularly fractions. The teaching of fractions is a challenging area at primary level yet lays the foundation for understanding different topics in upper grades such as algebra, ratio and proportion, statistics and probability (Van de Walle, Karp & Bay-Williams, 2010; Lamon, 1999; Litwiller & Bright, 2002).

In 1993 the Namibian government implemented a Basic Education Teacher Diploma (BETD) programme at all four Colleges of Education in the country (Windhoek, Caprivi, Rundu, and Ongwediva). These colleges have since been incorporated as satellite campuses into the University of Namibia (UNAM). The BETD program aims to produce teachers who can
meet the demands and rise to the challenges of the post-independence basic education system. Through this teacher training programme, student teachers are exposed to a variety of teaching and learning styles and strategies, seeking to equip them to become competent and professional teachers (Namibia. Ministry of Basic Education, Sport and Culture [MBESC], 2004). This programme aims to strike a balance between subject knowledge on one hand, and professional skills on the other. It also emphasizes learner-centred pedagogy as well as reflective and analytical exposure to classroom situations so that the theory and practice can be integrated meaningfully for the benefit of the student teachers (Namibia. MBESC, 2004; Namibia. Ministry of Education [MoE], 2009).

After incorporating the four colleges into the University of Namibia at the beginning of 2011, a Bachelor of Education degree (BEd) was introduced at the university to cater for both lower and upper primary teachers. The BEd (Upper Primary) is a four-year programme focusing on training teachers for level 5-7, that is Grades 5-7.

I am a teacher educator on the Mathematics Education course at one of the UNAM satellite campuses. I am involved with training student teachers (the BETD – until 2012, and now the BEd) to become Mathematics teachers at upper primary level (Grades 5-7). I have noted with disappointment that many student teachers, especially those majoring in Mathematics at level 5-7, struggle with many mathematical topics, but most especially the topic of fractions. In my experience, the student teachers’ performance in fraction tasks has been unsatisfactory compared to other topics in the Mathematics Education course. For some student teachers, their college/university understanding of fractions and how to teach fractions has no positive impact on their understanding of the concept. I have observed this during micro-teaching and when carrying out routine school visits to students who were deployed in the field.

The following examples are drawn from my experience in observing student teachers teaching fractional numbers and they demonstrate problems that may result from their prior knowledge of fractions. One example is when student teachers’ prior knowledge of a fraction concept refers only to a part of a whole. I noticed that when teaching other interpretations of a fraction, such as a quotient, this lack of understanding causes problems. Another example is the student teachers’ approach of memorizing rules without any understanding. I noticed that when student teachers are asked something like \( \frac{3}{4} \div \frac{1}{2} \), they will automatically tell you to do a reciprocal of the second fraction or to invert the second fraction.
and multiply. If one asks why, they are unable to explain their reasoning. This causes a conflict in teacher training, as when I teach fractions I always incorporate reality and the use of teaching aids in order to facilitate their understanding of fractions. Finally, students are not used to using proper fraction names such as ‘a half’, ‘two-thirds’, and so on, but rather say ‘one over two’, ‘two over three’, and so on. All these examples create a conflict between students’ prior practice and what the Mathematics Education course recommends for the effective teaching of fractions. As a result, student teachers tend not to appropriate the new practice taught on their Mathematics Education course as they continue using their old ideas of practice from the way they were taught fractions.

These observations prompted me to carry out an investigation, using a sample of BETD students at my institution, to better understand the factors that shape students’ understanding and ability to teach fractions.

**Aim of the research and research questions**

The main purpose of this study was to better inform the practice of training teachers to teach fractional numbers. My hope was that this research would highlight the difficult task of instructing upper primary pre-service teachers in teaching fractions, with the aim of increasing both the student teachers’ knowledge of the fraction content of the syllabus and their knowledge of how to teach the content to the learners. I focused on the following research questions:

1. How do student teachers teach fractions?
2. How does the student teachers’ experience of the BETD mathematics education course influence their teaching of fractions?
3. What is the student teachers’ previous experience of learning and teaching fractions?

The analysis of these research questions would enable me to identify possible influences on students’ appropriation of taught knowledge and practice into their own teaching practice.

**Literature review**

It is clear from the literature that the topic of fractions is deemed to be difficult to understand as well as to teach by many teachers (Ma, 1999; Post, Cramer, Behr, Lesh & Harel, 1993); and many learners find it very difficult to learn (Streefland, 1991; Gould, 2005). Several researchers have noted how children’s whole number schemes can interfere with their
effort to learn fractions (Ni & Zhou, 2005; Bezuk, 1988). Stafylidou and Vosniadou (2004) state that one of the reasons why fractions are systematically misrepresented is that they are not consistent with natural number counting principles. This simply means that children’s prior knowledge of whole numbers both supports and inhibits their understanding and skills of working with fractions.

Marshall (1993) supports the assumption that mastering the five interpretations of fractions (quotient, part-whole, measure, operator and ratio) contributes towards acquiring proficiency in fractions. It is suggested that when teaching fractions, teachers need to help learners to develop a profound understanding of the different interpretations of fractions. So instead of rushing to provide them with different algorithms to execute operations on fractions, teachers should place more emphasis on conceptual understanding (Lamon, 2007; Marshall, 1993).

Other researchers suggested ways for enhancing and developing how children understand fractions in the classroom. For instance, it is suggested that when fractions are introduced, the fraction symbols should be delayed until their concept is stable. It is advocated that initially children should rather be introduced to writing names in words, e.g. ‘one-quarter’ or ‘one-fourth’ instead of using numerals alone, e.g. $\frac{1}{4}$ (Newstead & Murray, 1998; Mack, 1995). It is also suggested that the teacher should introduce fractions in the context of sharing situations as these bring forth the pre-knowledge that the children bring with them to the classrooms and this can be used to introduce fractions (Murray, Olivier & Human, 1996; Mack, 1990).

Siebert and Gaskin (2006) discuss some of common ways of talking about fractions when teaching using phrases such as ‘out of’ or ‘over’, such as ‘4 out of 7’ or ‘4 over 7’ for $\frac{4}{7}$. They point out that these phrases involve different language from that of partitioning and iterating as well as a different image. This is so because using ‘out of’ makes learners see 7 things presented, then they take 4 from these. They further explain that in both cases learners see the numerator and denominator of the fraction as merely whole numbers (Siebert & Gaskin, 2006). Different research studies suggest that it is vitally important when teaching fractions for the teacher to give learners ample experience with a variety of materials (Baroody & Hume, 1991; Riddle & Rodzwell, 2000). Baroody and Hume (1991) further indicate that mathematics instruction should focus more on ‘why’ to help learners understand the underlying rationale for procedures. Riddle and Rodzwell (2000) emphasize that when learners ask ‘why’
questions, teachers should not use responses such as “because it works”, “just trust me on this”, “you don’t need to know that”. These reinforce the belief that mathematics entails memorizing and using procedures and rules mechanically without thinking. They suggest that teachers should focus on developing learners’ conceptual understanding along with procedural fluency of fractions in their teaching. Kilpatrick, Swafford and Findell (2001) emphasize that in their teaching of fractions, teachers should design mathematical work to challenge their learners’ thinking and to elicit variations in their strategies and solutions. They further comment that teachers should aim at developing fluency with rules and procedures with a focus on their underlying meanings or justification.

Fuller’s (1997) study examined content knowledge of experienced and novice primary school Mathematics teachers and found that both groups possessed primarily procedural knowledge of fractions. These Mathematics teachers emphasized procedures in their teaching with little attention to explanations and justifications (Ball, 1991). Since most of the Mathematics teachers experienced procedural instruction from their early schooling years, the teacher education challenge becomes one of “helping teachers transcend their own school experiences with mathematics in order to create new practices of mathematical pedagogy” (Ball, 1993, p. 395).

It has been indicated by several researchers that pre-service teachers’ understanding of fraction content knowledge is very weak (Simon, 1993; Cramer, Post & del Mas, 2002). Evidence through Ball’s (1990) research revealed that student teachers have difficulty with the concept of fractions and the meaning of division of fractions. Chinnappan’s (2000) research shows that the pre-service teachers have trouble explaining fractions and why algorithms work. Different classroom observations revealed that many student teachers possess only rote understanding of the different fraction algorithms (Borko, et al., 1992). With regard to developing the concept of fractions, it is noted that fractions are indeed difficult for primary school learners and that student teachers should be able to provide learners with instruction in fractions beyond the common part-whole relationships, including looking at fractions as quotient, operator and as ratio (Conference Board of Mathematical Sciences [CBMS], 2001).

Kieren (1992) and van de Walle, et al. (2010) explain how formal fraction notation and symbolism are used to represent the language of rational numbers. However, they caution that this can be misleading for
learners. Van de Walle, et al. (2010) add that the importance in fraction terminology lies not in whether formal (numerator/denominator) or informal (top/bottom) terminology is used, but in whether teachers are providing conceptually correct explanations of the terms to the learners. Additionally, Schoenfeld and Kilpatrick (2008) assert that teachers must have a firm grasp of a variety of ways of representing fractions, to enable them to guide learners to navigate the territory of problems involving fractions.

**Methodology**

This research was conducted using a qualitative case study method. According to Miles and Huberman (1994), in the qualitative approach “the researcher attempts to capture data on the perceptions of local actors ‘from the inside’, through a process of deep attentiveness, of empathetic understanding, and suspending preconceptions about the topic under discussion” (p. 6). Cohen, Manion and Morrison (2007) state that a case study “provides a unique example of real people in real situations”, in that it enables readers to understand ideas more clearly rather than simply being presented with ‘abstract theories’ or ‘principles’ (p. 253). Ary, Jacobs, Razavieh and Sorensen (2006) add that case studies provide an “intensive description and analysis of a phenomenon or social unit such as an individual, group, institution, or community” (p. 456). Merriam (2009) indicates that the content of the case study involves situating the case within its setting, which may be physical, social, historical and/or economic, depending on the case. In addition, one of the hallmarks of the case study as considered by Hitchcock and Hughes (1995) is that “it focuses on individual actors or groups of actors, and seeks to understand their perception of events” (p. 317).

In this study I engaged with selected student teachers from the year 3 BETD Mathematics majors for level 5-7, doing their teaching practice at different primary schools in Namibia. I explored the student teachers’ experiences and perceptions when teaching fractions. My unit of analysis was the five student teachers teaching fractions to Grades 5-7. I worked with these student teacher by observing them and conducting both individual and focus group interviews. This enabled me to examine their experiences in terms of their prior knowledge, their taught knowledge on the mathematics course, as well as their developed practice in terms of fraction teaching.
Findings and discussion

The main findings of this study are organized according to the three research questions as follows.

**Student Teachers’ teaching**
The first research question looked at participants’ practice of teaching fractions, the way they taught, how they prepared and presented their lessons, what methods and teaching strategies they employed in their teaching, and so on.

**(a) Doing calculations**
The data analysis strongly revealed that student teachers saw mathematics as just about doing calculations. Through their interviews they testified that the learners’ practice of doing lots of calculations with fractions would enhance their skills of calculating fraction problems, as they believed that ‘practice makes perfect’. They explained that through the drill and practice of skills, the student teachers tested whether their learners could put into practice what they had taught them about fractions or not. Student teachers indicated that different learners learn at different paces and that was the main reason they designed activities involving different calculations for their learners. Apparently, they believed that ‘the more you give, the better the learning becomes’, and that was how they learned both in school and from the Mathematics Education course.

**(b) Rules and procedures**
The student teachers emphasized the importance of mathematical rules and procedures in their teaching of fractions. Their view of learning mathematics, and fractions in particular, was that one should master the rules and procedures provided by the teacher. Most of them appeared to believe that knowing mathematics means being able to produce a correct answer that is wanted by the teacher, following the rules step-by-step, but with little or no knowledge of why the algorithm works. What is suggested here is that to learn mathematics for the student teachers means to follow the rules stipulated by the teacher, and do lots of drill and practice, as this was how they experienced the learning of fractions in their early schooling.
(c) Passive teaching
Evidence in the data pointed to the use of passive teaching in fraction lessons. This was seen when one student teacher presented a fraction representation in one of the lessons. He asked questions and rejected all learner responses, but could not help the children to understand what was useful for the particular lesson taught. Instead, as a result of his previous experience the student teacher focused on the specific work that he wanted to include in the lesson. As a result, the learners were forced to become passive and merely listen to what the teacher was telling them about the representation he provided.

(d) Use of different teaching approaches
The data analysis showed that as a result of their experiences on the BETD course, the student teachers used different teaching approaches in their fraction lessons. A positive effect of this was observed when they tried to find out what learners’ prior knowledge was. This is in line with the learner-centred approach to starting a Mathematics lesson. Data analysis also revealed that in some lessons class discussion encouraged learners’ active participation. The data however indicated that the student teachers made use of a naive interpretation of learner-centred education through ‘class discussion’ and ‘group work’.

BETD Mathematics Education course experiences
The second research question explored the participants’ experience in terms of the BETD Mathematics Education course’s influence on their teaching practice. It investigated how the participants related their skills and knowledge they learned on the mathematics education course to their fraction teaching.

(a) To satisfy the course criteria
Some student teachers distributed ‘teaching aids’ to their learners without incorporating the teaching aids into the teaching. This evidence showed that the student teachers’ thinking in this particular case was that by including this ‘teaching aid’ it would satisfy the criterion of ‘using teaching aids’ in one’s teaching of fractions. But the intention of the student teacher here was not to improve learning, but merely to satisfy the course assessment criteria.

(b) Relevance
The student teacher (from part (a) above) did not appear to see
mathematics as real, but symbolic, as he could not see the connection of his ‘teaching aid’ to the particular content taught. Even though the learners could see, touch and feel the ‘teaching aid’, they were not guided on how to connect what they saw, touched and felt with the lesson on fractions. As a result, the particular ‘teaching aid’ was disconnected from reality. This means though trained and exposed to different uses of teaching aids in the Mathematics lessons, some student teachers were unable to see the importance of connections in Mathematics lessons.

(c) Redirecting learners’ misconceptions
Evidence from the data revealed that not all of the student teachers lacked fraction understanding in their teaching. This was revealed when they managed to correct their learners’ misconceptions in different cases. For instance, during addition and subtraction in a fraction lesson, a student teacher redirected the learners and showed them the proper way. This aspect showed that as a result of the BETD Mathematics Education course, some student teachers were able to teach and show learners what to do about fractions. They applied and put to use their correct fraction understanding in their teaching.

(d) Lack of understanding leading to fear and anxiety
In their interviews, the participants stated that they greatly appreciated the fact that they furthered their own understanding of fractions through undertaking mathematics education course training in BETD. They however disclosed that they still felt that their mathematical content knowledge and pedagogical content knowledge needed to be strengthened. They felt that they lacked the pedagogical skills needed to design appropriate teaching aids for fraction lessons. These student teachers felt that their fraction content knowledge was not up to par for them to effectively deliver the fraction lessons with confidence. This lack of proper fraction understanding led them to experience fear and anxiety during their teaching. They highlighted that they experienced anxiety because they did not know what to do if, for instance, they were asked different questions by their learners. They were also constantly concerned with whether their learners would grasp what they were teaching them or not.
Student Teachers previous experiences of fractions
The third research question looked at the participants’ previous experience of fractions and fraction teaching. It explored how this impacted on their fraction understanding and fraction teaching.

(a) Symbolic representations
The student teachers indicated that they based their fraction teaching mostly on what they were taught in their early years of schooling. This was done using few or no manipulatives at all, as they were taught fractions as symbolic representations. Another finding that emerged was that the student teachers felt comfortable and at ease using the ‘old way’ of teaching where no reality was incorporated in their fraction teaching. A significant finding from the data here is that the student teachers viewed mathematics as the use of symbols such as $\frac{1}{2}$, $\frac{1}{3}$ and so on, and they interpreted mathematics, particularly fractions, as having nothing to do with reality. It is suggested here that the training and the teaching that most student teachers went through did not change their beliefs and improve their knowledge of fractions.

(b) Use of different terminology
A common finding during the data analysis process was that most teacher trainees used incorrect terminology such as ‘1 over 2’, ‘3 over 4’, instead of using the correct fraction name such ‘half’ or ‘three-quarters’, as guided in BETD. This evidence reflected the student teachers’ background of learning fractions as well as their belief and knowledge of what a fraction is. The end result of this was that the student teachers did not completely adopt the knowledge they gained through the fraction teaching offered in their training.

(c) Fraction as a pair of two different whole numbers
Another finding was that one participant viewed a fraction as a pair of two different whole numbers. This was seen when this student teacher encouraged the learners to break a fraction such as $\frac{1}{2}$ into parts and treat them as whole numbers rather than part of a fraction. The implication here is that the student teacher had not made the transition to seeing the composite symbol $\frac{1}{2}$ or 2/4 as representing a unit (one thing). This suggested that even though the student teacher was taught about fractions, a misconception from his previous knowledge of fractions (that a fraction was two different entities that could be dealt with separately) was not altered.
(d) Alignment and reverting
Some student teachers showed the intention of teaching fractions in a way that was aligned with the practice on the course. They showed these alignments when they attempted to put into practice the methods and techniques of teaching fractions, using prepared teaching aids. But due to lack of preparation and testing in advance whether these would work, the method was not completely successful. This led to the student teacher becoming uncomfortable and frustrated to the extent that she reverted to the ‘old way’ of teaching (which she found non-challenging and comfortable). That is, when the student teachers felt that when the method taught on the Mathematics Education course was not working well, then they resorted to the use of ‘traditional ways’ of teaching – the way they were previously taught in schools. Here the reason for failure was not the new practice, but rather a practical matter of preparation and practice in the use of the new method, on the side of the student teachers.

Conclusion
In conclusion, I agree with Ball (1988) who argued that during their training, pre-service teachers need to ‘unlearn’ what they know about teaching and learning of mathematics, specifically fractions. As Borko, et al. (1992) reported, the teachers’ knowledge and beliefs about the role of practice in learning to teach Mathematics often inhibits the effort to improve their knowledge before they become teachers of Mathematics. It is suggested that for preparation programmes to be more effective, they should focus on helping student teachers acquire the tools they will need to learn to teach Mathematics rather than the finished competencies of effective teaching (Hiebert, Gallimore & Stigler, 2002; Hiebert, Morris, & Glass, 2003).

I therefore propose the following ideas on how to enhance the student teachers’ knowledge and understanding of fractions, as well as how to effectively learn how to teach mathematics and fractions in particular.

- In order for the student teachers to teach fractions for understanding, they should emphasize the connections between real-life problems and the fraction notation used to represent the problem. That is, fraction problems should be presented in meaningful, real-world contexts, as this encourages learners to use their learner-invented problem solving strategies, instead of memorized rules and procedures.
• Student teachers need to have a thorough and deep knowledge of fraction concepts and operations to enable them to teach fractions effectively, and use different appropriate representations for each situation.

• Student teachers should be properly guided in their training about what approaches to employ in the teaching of fractions, both the how and why.

• Student teachers need to work with units of fractions, such as counting in fractions, e.g. using ¼, ½ and so on, in order for them to conceptualize the meaning of a fraction.

• As a teacher educator for Mathematics Education courses, one can take the student teachers’ existing knowledge of fractions, and challenge and solidify this knowledge to enable them to move beyond the part-whole representation of fractions.

REFERENCES


AN INVESTIGATION OF THE EXPERIENCE OF SELECTED GRADE 7 TEACHERS IN USING THE SINGAPORE BAR MODEL (SBM) IN THE TEACHING OF MATHEMATICAL WORD PROBLEMS: A NAMIBIAN CASE STUDY

FILLEMON NDINELAGO VATILIFA

The Singapore Bar Model (SBM) is a method adopted by the Singapore Mathematics Curriculum (SMC) for the teaching and learning of mathematical problem solving. The aim of the method is to enhance learners’ sense-making by visually representing a given mathematical situation. The purpose of this study was to establish whether the use of the SBM, in the teaching and learning of mathematical word problem solving, is a viable option in the Namibian context. The case study involved three Grade 7 Mathematics teachers and engaged with their perceptions and experiences of using the SBM in their teaching. The findings of this study suggest that there is a close link between the use of the SBM and the Namibian policy of learner-centred education. It is recommended that the use of the SBM method in Namibian classrooms should be encouraged and promoted.

Introduction and background context
Mathematical word problems are a central component of the discipline of mathematics (Kilpatrick, Swafford & Findell, 2001). Word problems provide a meaningful link between mathematics and reality. Bonotto (2009) advocates that classroom mathematics should be connected to real life situations. However, there are different viewpoints regarding the function of word problems in mathematics education. Researchers and
drafters of new curricula generally relate word problems to problem solving and application, whereas many teachers see word problems as mere exercises in the four basic operations (Bonotto, 2009). Hines (2008) states that instead of mathematics problem solving being a tool to read and process mathematical situations, it is often relegated to an imitation of procedures whereby teachers provide students with linear steps to solving problems. This denies students the opportunity of making personal meaning of mathematical word situations. This view is supported by O’Connell (2000) who stated that mathematical meaning making is the ability to personally construct meaning, and students should therefore be enabled to enter this meaning making space to solve mathematical word problems effectively.

The Singapore Education System, through its Singapore Mathematics Curriculum (SMC), uses a model that promotes the development of mathematical thinking and problem solving skills (Fan & Zhu, 2007). The approach is called the Singapore Bar Model (SBM) method and uses rectangular bars to represent and model word problems, thereby enabling learners to visualise problems and solve them more practically than by simply applying a formula.

Given that the examiners’ reports on learners’ performance in Mathematics for Grade 7, 10 and 12 national examinations indicate that learners lack proficiency in solving mathematical word problems (Namibia. MEC, 2010), this study explored the use of the SBM method in the Namibian educational context. In particular I looked at mathematical problem solving, the Singaporean method of solving word problems and the ‘tripartite’ relationship between the Singaporean method, the Namibian learner-centred approach (LCA) and Kilpatrick, Swafford and Findell’s (2001) advocacy of teaching for mathematical proficiency.

**Aims of the research**

The main purpose of the study was to establish whether the Singapore Bar Model as an approach to solving mathematical word problems is a viable teaching option in the Namibian context. The study investigated the experiences of selected Grade 7 teachers in implementing the SBM in teaching mathematical word problems. In particular, the study asked the following questions:

- What are the selected teachers’ experiences and perceptions of using the SBM?
How could the SBM support teaching for mathematical proficiency in the Namibian classroom?

**Literature review**

Research has indicated that teachers should be able to support learners to develop their ability in problem solving through appropriate teaching strategies. Chang (as cited in Fan & Zhu, 2007) suggests that cooperative learning, heuristic instruction and using sense making activities could be used to promote aptitude in problem solving. For learners to learn sensibly and effectively, Bonotto (2009) suggests that teachers should use activities that relate more to the experiential world of the learners.

Bonotto (2009) emphasizes the importance of connecting mathematical word problems in the classrooms with real-life situations. This can be accomplished, for example, through classroom activities using cultural and interactive teaching methods. Bonotto (2009) suggests that classroom practice in general needs to adapt to achieve situations of realistic mathematical modelling that are real-world based, are more relatable to the experiential worlds of the learners, and consistent with sense-making dispositions.

The Singapore Bar Model approach was adopted by the Ministry of Education of Singapore to help learners improve their performance in mastering difficult mathematical word problems, and to support the transition to thinking symbolically (Hoven & Garelick, 2007). The SBM method explicitly makes use of modelling by representing a mathematical problem situation with a set of rectangular bars. Following are examples that illustrate the use of the SBM, specifically the part-whole model, the comparison model, and the before-after change model.

**The part-whole model**

*Ms. Courtney bought a pen for N$12 and a book for N$15. She paid with a N$50 note. How much change did she get?*

**Solution:**

\[ \text{N$50} - \text{N$12} - \text{N$15} = \text{N$23} \]

**Explanation**

The whole bar represents the total amount Mrs Courtney gave the cashier, i.e. N$50. The first part of the bar represents the amount she paid for the pen while the second part represents the amount she paid for the book. Hence the remaining part represents the change she gets.
The comparison model
A man with a height of 1.80m is 35cm taller than his daughter who in turn is 5cm shorter than her mother. How tall is the mother?

Solution:

\[
\begin{align*}
\text{Man} & : 1.80m \\
\text{Daughter} & : 1.45m \\
\text{Mother} & : 1.45m + 0.05m = 1.50m \\
\end{align*}
\]

Explanation
In the second bar the daughter’s height = the father’s height – 0.35m
In the third bar the mother’s height = the daughter’s height + 0.05m

The before-after model
Penny and Jenny have equal amounts of money. If Penny spends N$18 and Jenny spends N$25, then Penny will have twice as much money left as Jenny has left. How much money did they each have in the beginning?

Solution:

\[
\begin{align*}
\text{Penny} & : \text{Before} \implies \text{After} \\
\text{Jenny} & : \text{Before} \implies \text{After} \\
N$18 & \implies N$7 & \implies N$7 & \implies N$7 \\
N$25 & \implies N$7 & \implies N$7 & \implies ? \\
\end{align*}
\]

Each had N$25 + N$7 = N$32

Explanation
Before: They all start off with an equal amount of money
After: When Penny spends N$18, Jenny spends N$25 (18+7)
For Penny’s remainder to be twice as much as Jenny’s, the difference between N$25 and N$18 has to be doubled (i.e. N$7 × 2)
Contrary to more traditional mathematical modelling, which tends to be associated with high school pure and applied mathematics to solve real problems, mathematical modelling as mathematical problem solving focuses on the students’ representational fluency through the flexible use of mathematical ideas. When students engage in model-eliciting activities, their internal conceptual systems are continually projected externally (Lesh & Doerr, 2003). This process makes the sense-making aspects of learners’ mathematical reasoning visible.

Alongside other Singaporean methods, the SBM has received increasing attention since Singapore was placed first in the TIMSS of 1995, 1999 and 2003 (Singapore. MoE, 2009). Wong, et al. (2009) suggested that it is possible that the use of the SBM may have contributed to the top performance of Singapore pupils in TIMMS. This study thus aimed at discovering whether the SBM approach could be used in the Namibian classroom to enhance the teaching and learning of mathematical world problems.

Methodology

This case study involved three teachers selected from three schools in the Oshana region. The study, which was framed within an interpretive paradigm, focused on the participating teachers’ experience and perceptions of using the SBM method in teaching mathematical word problems.

The design of the study was structured around four phases. The first phase took the form of an orientation workshop in which fifteen Grade 7 teachers were introduced to the SBM method and encouraged to make use of the method in their own classes. Three teachers from the workshop volunteered to take part in the succeeding phases of the study. The second phase took the form of classroom observations. Two lessons for each of the three teachers were video-recorded. These lessons involved the teachers implementing the SBM method in their classroom. In the third phase the three participating teachers completed a questionnaire regarding their understanding of the SBM method and how they made use of it in their teaching. Each of the teachers was also interviewed individually. The video-recorded lessons as well as the questionnaires were used to inform the interviews. The final phase took the form of a focus group discussion in which the participants were asked to reflect on their experiences.
In terms of data analysis, all data collected through observations, questionnaires, interviews and focus group discussions was analysed in terms of Kilpatrick, et al.’s (2001) five strands of teaching for proficiency, namely conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition.

Findings and discussion
The study showed that there is a close link between the use of the SBM and the Namibian policy of Learner-Centred Education (LCE). Both the SBM and LCE are articulated policies in the Singaporean and Namibian education systems respectively. Whereas the SBM is a heuristic tool for teaching mathematical word problems that is anchored in the Singapore Mathematics Curriculum, LCE is an approach to teaching through discovery methods. Both the SBM and LCE put the learner at the centre of his/her own learning. The participating teachers in this research felt that the SBM was successful in helping their learners acquire mathematical proficiency through deductive learning.

Conceptual understanding
The three teachers concurred that visualisation plays an important role in concept building and concept formation. For this reason the SBM as a visualisation tool helps learners to develop conceptual understanding in mathematics. The teachers also believed that through the use of the SBM approach, learners are provided with an opportunity to become responsible for their own learning. The SBM method promotes independent thinking, and learners find their own ways of presenting concepts and ideas.

The participating teachers also felt that the method represents a powerful means of responding to and dealing with learners’ misconceptions in mathematical word problem solving since the SBM approach provides for a systematic presentation of information. This supports the learners in detecting their mistakes and helps them avoid misconceptions.

Procedural fluency
From the data analysis it was evident that all three teachers had similar experiences. All the teachers stated that the SBM approach supported learners to be able to generate their own methods and strategies to solve mathematical word problems. They indicated that the visual nature of the
model helped their learners to develop strategies for solving word problems. The use of visual bars helped learners to identify the required information which they then used to develop their own strategies.

The teachers believed that the model supported the acquisition of mathematical understanding. “Learners learn mathematical skills easily if they learn them with understanding” (Kilpatrick, et al., 2001, p. 120). Conversely, learners would find it difficult to deepen their mathematical understanding if they did not have sufficient procedural fluency. Thus the SBM method enabled learners in the acquisition of conceptual understanding, which in turn helped them to generate problem solving strategies. This resonates with Kilpatrick, et al. (2001) who assert that learners are more likely to be able to modify or adapt procedures if they have been learnt with understanding. The teachers found that when learners constructed the required bars, ideas for finding an appropriate strategy came naturally. The SBM method, as a teaching and learning heuristic, was successful in terms of helping learners by means of a concrete approach to learning (Khoh, 2002).

**Strategic competence**

Strategic competence refers to the ability to formulate mathematical problems, represent them, and then solve them (Kilpatrick, et al., 2001). Participating teachers found that when learners drew the bars using the SBM method it helped them to conceptualise the problem at hand and this helped them to choose appropriate procedures. The teachers considered that modelling through bars helped their learners formulate and represent mathematical word problems into mathematical symbols. Learners could then use the mathematical symbols to devise methods and strategies to find the solution to the problems.

Kilpatrick, et al. (2001) highlight that there is a mutually supportive relationship between the strands of strategic competence and conceptual understanding when learners solve mathematical problems. All three teachers acknowledged that it was the visual nature of the SBM method that assisted the learners to interpret, represent and eventually find suitable strategies of problem solving. The teachers indicated that the model gave their learners an opportunity to present the word problems in pictorial forms thereby enabling them to see the given, the known, and the unknown features in the word expressions. In this way learners were more likely to ignore the irrelevant features when devising strategies for solutions.
Adaptive reasoning
The participating teachers acknowledged that drawing the bars required learners to make sense of the given word problems. Through the process of drawing the pictorial model, learners needed to engage with all the information required to find the solution to the problem. Planning and deciding how to draw the bars for a mathematical word problem requires logic, critical thinking and careful attention to detail, all of which relate to aspects of adaptive reasoning.

The three participants also indicated that the increased reasoning of learners during the process of drawing the bar models would improve other strands such as conceptual understanding, procedural fluency and strategic competence. This is supported by Kilpatrick, et al. (2001) who remark that “adaptive reasoning interacts with the other strands of proficiency, particularly during problem solving” (p. 130). All three teachers agreed that the SBM method supported learners in recognising the connections between pieces of mathematical information. These connections encouraged them to think logically and critically in order to find solutions to the given word problem.

Productive disposition
When asked whether they enjoyed teaching mathematical word problems using the SBM method, all three teachers indicated that they had. This shows that the model had a positive effect on their disposition towards mathematics. How a teacher views mathematics and its learning affects that teacher’s teaching practice, which ultimately affects not only what the students learn but how they view themselves as mathematics learners. The participating teachers’ positive experience with the SBM method thus encouraged them to instil a positive disposition in their learners.

All three teachers expressed the idea that the use of visualisation helped their learners to ‘see’ mathematics, thereby making it more enjoyable for them. The SBM method instilled confidence in learners, and this is supported by the fact that they not only used this method in the classroom, but also when they wrote Mathematics examinations. This shows that the method was successful in developing learners’ positive disposition towards mathematics and contributed to their overall mathematical proficiency. As Kilpatrick, et al. (2001) remark, learners who have a positive productive disposition in mathematics are more likely to develop the other four strands as well.

The participating teachers showed explicitly that through the use of the SBM learners became more responsible for their own learning. This
occurred because the method encouraged the learners to adapt their thinking and develop their own strategies for comprehension, presenting and finding solutions to mathematical word problems. The teachers indicated that when using the SBM method their learners demonstrated the acquisition of elements of all the five strands of mathematical proficiency, as proposed by Kilpatrick, et al. (2001). The teachers indicated that the visual nature of the model helped the learners to concretise word problems, thereby making it easy for them to solve them with understanding. The teachers therefore perceived that the use of the SBM as a tool for teaching mathematical word problem solving would enhance the acquisition of mathematical proficiency.

**Conclusion**

In this study, the SBM proved to be a significant modelling tool for learning and teaching mathematics, particularly when used in the context of mathematical word problem solving. Therefore, teaching through the use of SBM in solving problems aligns well with the Namibian education system that advocates learning through discovery. Although this case study only used a small sample of teachers in a very specific context, this study showed clearly that the introduction of the SBM has the potential to improve the teaching of word problems and should be considered as a teaching approach in Namibia. Specifically, my findings suggest that:

- Mathematical word problems should be presented in ways that are meaningful to the learners. For example, learners should be encouraged to visualise mathematical word problems.
- Learners should be taught how to use mathematics to model a given problem. The SBM method provides a very effective means to model problems.
- Teachers ought to provide learners with opportunities to share and co-operate when dealing with mathematical word problem solving lessons. The SBM approach facilitates this very well.
- The SBM method aligns well with the Namibian policy of learner-centred education, and should thus be piloted in many more schools.
- Mathematics teachers should be exposed to model-eliciting activities that help learners to concretise mathematical problems. This would provide teachers with the necessary skill and experience for using heuristics in the teaching of Mathematics for mathematical proficiency.
Mathematical word problems should be drawn from real-life examples.

The SBM should be introduced to learners at an early age as this would form a good foundation for problem solving later in their school career.

I hope that this study contributes towards encouraging teachers and other educationists such as policy makers to explore the use of this approach in solving mathematical word problems. The experiences of the participating teachers should be considered by other practicing teachers and curriculum developers of Namibia in order to contribute to the process of reforming mathematics education in this country.

REFERENCES


This case study, involving two purposefully selected teachers and one educational officer, investigated Mathematics teachers’ practices that have led to the persistence of traditional teaching practices in Grade 9 Mathematics classrooms. The study was conducted from a Learner-Centred Education (LCE) perspective in the Kavango region. Typical case study tools such as questionnaires, observations and interviews were used to gather data. The study revealed that the persistence of traditional teaching practices in Mathematics classrooms is partly due to inadequate practical training in the learner-centred approach. All three participants had adequate theoretical knowledge of LCE but found it difficult to implement. Inconsistent policy issues are also a contributing factor to the persistence of traditional teaching practices, since some of the educational policies are in conflict with the implementation of LCE. Moreover, teachers seem to be faced with many other challenges such as over-crowding in classrooms, lack of teaching materials, lack of support from other Mathematics teachers, and learners’ negative attitude towards Mathematics.

Introduction

Learner-Centred Education (LCE) was introduced in schools when Namibia gained independence in 1990. This was seen as a preferable alternative to the inferior Bantu education which black Namibians were exposed to under the previous regime. However, the implementation of LCE in mathematics classrooms has proved problematic. Traditional teaching methods still persist. This trend is of concern as it could potentially undermine the national goals of access, equity, quality and
democracy (Namibia. Ministry of Basic Education and Culture [MBEC], 1993). Mathematics is still perceived as one of the most difficult subjects in the school curriculum and there has been no significant improvement over the years with regard to the performance of learners.

It is against this background that I sought to investigate Mathematics teachers’ interpretation and implementation of the concept of LCE, so as to understand why traditional teaching practices still persist in Mathematics classrooms.

After independence, the Namibian government embarked upon a major educational reform process to overhaul the inherited segregated Bantu Education system. This required a paradigm shift in education. A LCE approach to teaching and learning was opted for, since the inefficient and outdated Teacher-Centred Education (TCE) approach was not consistent with the national goal of Education for All (MBEC, 1993). LCE is an educational framework that places the learner at the centre of all teaching and learning activities. The learners’ prior knowledge plays an important role in their learning and personal understanding. According to Jaworski (1994, p. 16), “What we know is the accumulation of all our experiences. Every new encounter either adds to that experience or challenges it.” Learners should therefore not be regarded as empty vessels in any teaching-learning situation.

For the subject of Mathematics, however, the new approach has not improved the quality of learning and the performance of learners. The trends from the colonial era with regard to learners’ negative attitude towards Mathematics and poor performance in Mathematics are still prevalent. Mathematics is still perceived by many as a subject meant for a selected few or elites only. This raises a number of questions about the implementation of LCE by Mathematics teachers. The Ministry of Education recently made Mathematics a compulsory subject for Grades 1-12. When this research was conducted in 2007, Mathematics was a compulsory subject up to Grade 10, and only a few learners made it to the senior secondary phase (Grades 11 and 12). To now expect all learners to succeed in Mathematics up to Grade 12 under the current system is, in my view, a little unrealistic. In my experience many Mathematics teachers find it difficult to implement a LCE approach in their teaching. It is therefore imperative that research of this nature be conducted to identify discrepancies between the policy of LCE and the way Mathematics is actually taught in schools. Measures need to be put in place to ensure that learners are well prepared for senior secondary level Mathematics. Effective LCE teaching methods should thus be implemented from the
junior primary phase in order to ensure a smooth transition from one phase to the next.

Considering our history, it is highly likely that some teachers are pedagogically stuck in the past. They might be using positivist methods to achieve constructivist goals which, according to Hinchey (1998), is not effective.

**Aims of the research**

The aims of this research project were, first, to investigate the practices of Mathematics teachers that have conduced to the persistence of traditional teaching methods in mathematics classrooms; and secondly, to establish the relationship between Mathematics teachers’ interpretation of LCE and their classroom practices.

The research questions that framed this study were:

1. What kinds of practices have led to the persistence of traditional teaching methods?
2. How do Mathematics teachers interpret the concept of LCE?
3. Do Mathematics teachers’ interpretations of LCE align with their teaching methods?
4. Is LCE successfully implemented in Mathematics classrooms?

**Literature review**

Literature for this research was predominantly drawn from constructivist sources. Reform in education in Namibia was prompted by the need to correct the inherited imbalances in education from the colonial era. The Bantu education system was intentionally designed to perpetuate colonialism and deny black Namibians access to quality education (Amukugo, 1993; Christie, 1991; MBEC, 1993). The Namibian government was therefore compelled to take drastic measures to improve the quality of education in order to achieve total independence. A divisive type of education could not be tolerated in an independent Namibia. According to Molobi: “The real struggle now is to replace an undemocratic, coercive, ineffective and irrelevant education system with a democratic participatory and relevant alternative” (Molobi quoted in Christie, 1991, p. 14). For Namibia, this meant establishing a new educational framework. The framework that dominated the reform process was based on a learner-centred approach embedded in a constructivist worldview.
The implementation of LCE was however not a smooth process. The poor implementation of LCE in schools has been attributed to a number of factors, such as a lack of common understanding of the concept and how it should be put into practice (NIED, 2003; Squazzin & van Graan, 1999), and a dearth of teachers to model learner-centred methods. Some schools insist on the use of TCE as it saves time and makes classroom control easier. LCE is naively (mis)interpreted simply to mean group work and non-failure assessment (Macleod, et al., 2002; Crebbin, et al., 2008). It is evident in many classrooms that the concept of LCE is not fully understood and this has led to various misconceptions about LCE. It is therefore imperative to have a comprehensive definition of LCE to ensure that teachers share a common understanding as to which practices qualify as LCE and which ones do not.

Constructivists hold the belief that LCE is an educational framework that views the acquisition of knowledge as an active process of knowledge construction (Hinchey, 1998; Richardson, 1997). LCE places emphasis on two principles, namely the active nature of the process of knowledge acquisition and the adaptability of the knowledge acquired (Jarworski, 1994, p. 16). This implies that knowledge cannot be passively acquired by learners. They need to be actively involved in the learning process to understand and make sense of any concept that is being taught. The second principle refers to the ability of learners to use the acquired knowledge in different contexts. As stated by Ernest (1994, p. 1), “… the developing human intelligence also undergoes a process of adaption in order to fit with its circumstances and remain viable. Personal theories are constructed as constellations of concepts and are adapted by the twin processes of assimilation and accommodation in order to fit with the human organism’s world of experience.” Both principles play a very important role in the acquisition and application of mathematical knowledge.

Prior knowledge is another fundamental aspect of LCE that plays a crucial role in the learning process. According to Hinchey (1998), the personal experience of each learner plays an important role in the meaning they attach to facts. The inability of learners to establish a relationship between their prior knowledge and the new knowledge leads to frustrations and misconceptions, especially in Mathematics. Mathematics is a subject in which learners are expected to use knowledge from different mathematical concepts to solve problems. If learners cannot establish a relationship between the new knowledge and the old knowledge, then the new knowledge will not make sense to them.
Mathematical concepts cannot be learnt in isolation. As a result, it is important to use learners’ prior knowledge as a point of departure in the teaching process. We should not view learners as having flawed ideas that instruction must confront and replace (Smith, diSessa & Roschelle, 1993, p. 115).

Quality is the other important aspect of LCE. It is one of the educational goals of Namibia but it has received little attention (Crebbin, et al., 2008). The development brief for education, culture and training calls for an understanding of quality in a broader sense. It is not merely measured by the performance of learners in examinations. The quality of education is enhanced by good teacher education programmes, meaningful support for teachers from education officers, appropriate types of assessment, access, equity and the availability of resources (MBEC, 1993). TCE emanates from a behaviourist epistemology which assumes that knowledge is something that is out there waiting for us to find it. Behaviourists perceive knowledge as a “thing – factual and verifiable information resulting from scientific investigation” (Hinchey, 1998, p. 39). From this perspective, knowledge is perceived as some kind of unquestionable truth.

Knowledge in TCE-settings is about learning facts to gain more knowledge rather than to construct knowledge and make sense of facts. Learners are perceived as empty vessels while teachers are regarded as “providers” of knowledge. The teacher decides what is to be taught (content), how it is to be taught (methodology), as well as determining the pace of learning (Farrant, 1980, p. 129). This teaching approach disadvantages the learners as they do not play an active role in their own learning. In most instances, the teacher expects learners to reproduce facts exactly as they were presented to them. Learners are therefore perceived as passive recipients of knowledge.

Learners differ in many aspects and should therefore be treated as individuals with different learning needs. However, in TCE learners are regarded as uniform groups or classes with the same learning needs, which results in discrepancies in terms of knowledge acquisition (Farrant, 1980). Success in education is determined by learners’ ability to memorise and reproduce facts. TCE leans more towards procedural knowledge acquisition rather than conceptual knowledge acquisition since it promotes the memorisation of isolated bits of knowledge. Such knowledge has limited relevance as it cannot be applied in different contexts. A behaviourist view of Mathematics encourages teachers to cling to traditional teaching methods. A constructivist view of
Mathematics, however, argues that Mathematics, just like any other subject, can be taught using LCE (Ernest, 1994). Mathematics content should be taught in such a way that it makes sense to the learners. Abstract concepts should be transformed into less abstract concepts so that learners can attach meaning to them. Mathematics is a unique and precise language made up of numbers, symbols, diagrams, graphs, etc. This is what makes it abstract since learners rarely attach meaning to such symbols or diagrams. The teacher’s responsibility is thus to help learners make sense of the abstract mathematical language (Ernest, 1994) through profound cognitive restructuring and conceptual reorganisation (Cobb, quoted in Jarworski, 1994, p. 23).

The role of the teacher should be well defined in order to ensure that LCE is properly implemented. Some teachers assume the role of a spectator: they give learners group work and observe them from a distance. This is mistaken. Teachers are expected to think about what they are going to teach, how they are going to teach and whom they are going to teach. This is an intellectually demanding task on the part of the teacher (Clark, 1995). “In helping children learn, teachers must take abstract ideas and unpack them in ways that make concepts visible” (Kilpatrick, Swafford & Findell, 2001).

The successful implementation of LCE requires mathematics teachers to change their beliefs about Mathematics as a subject and what it means to teach and learn Mathematics. The traditional teaching methods that Mathematics teachers were exposed to at school influence the way that they themselves teach Mathematics, their beliefs and values. The recommended paradigm shift is therefore often in conflict with these beliefs and values.

Mathematics teachers need guidance in the implementation of LCE. Some teachers understand the concept of LCE quite well but they cannot put it into practice since there is no blueprint on how to implement LCE. According to Fennema and Nelson (1997, p. 20): “The motivation for helping teachers develop new forms of practice is high, but the means by which teachers actually do so are not well understood.” There are various challenges that have caused mathematics teachers to cling to traditional teaching methods. These range from a lack of exposure to LCE instruction, inadequate mathematics content, inability to interpret children’s mathematical language, and resistance to change due to deep-rooted beliefs in the teacher-centred approach (TCA).

Teachers need to see the need to change: “For some teachers to become invested sufficiently in this process of professional development,
they must first come to believe that their current practice is in some way problematic or at least change would be beneficial” (Cobb, Wood & Yackel, 1990 and Simon, 1994, cited in Fennema & Nelson, 1997, p. 291). Change in pedagogy depends on factors such as teachers’ attitudes towards the required change, their perceptions, knowledge and understanding of the new concepts, and the quality of supervision and assistance rendered by their supervisors.

**Research methodology**

This qualitative case study is rooted in the interpretive paradigm. Questionnaires, interviews and observations were the main tools for data collection. A questionnaire was used to select my participants as it required the respondents to indicate their teaching orientation. My intention was to secure the participation of a more learner-centred teacher, a teacher who practices both teacher-centredness and learner-centredness, and a more teacher-centred teacher. Interviews were conducted to establish my participants’ interpretations of the concepts LCE and TCE. Observations were then used to assess how the participants implemented LCE and to determine if what they said in the interviews aligned with their teaching methods.

This research was conducted at an urban school and a rural school on the outskirts of Rundu. Data was analysed using the following themes or aspects of the interview framework:

- The participant’s experience of learning mathematics in school
- Their source of inspiration to pursue the teaching profession
- Their teacher training
- Their definitions of LCE and TCE
- How they implement LCE
- What they regard as examples of L-C or T-C activities
- Advantages of using LCE
- Challenges that they encounter in trying to implement LCE
- Their messages or advice to their fellow mathematics teachers

One of the validity issues that confronted me was the possibility that, because LCE is a national educational policy, the participating teachers would not openly speak about their teacher-centred practice.
Findings

The study revealed that the participants seemed to have a common understanding of LCE since they all described it as a teaching approach that is centred on the learner. However, none of the participants made reference to constructivism as the paradigm underpinning LCE. LCE is indeed centred on the learner, but it is the notion that knowledge is constructed in the mind of the learner that clearly distinguishes LCE from TCE.

Participant A, whose practice is more L-C oriented, implemented LCE by defining new terms, involving learners in explaining concepts, engaging learners in outdoor mathematics activities, arranging her class in a L-C friendly manner and exposing learners to real-life examples. These are all important aspects of LCE. Participant B employed both L-C and T-C approaches. The nature of the content determined the approach she used. According to participant B, she chose to use LCE for easier topics and TCE for the more difficult topics.

Teacher B regarded the practice of eliciting learners’ prior knowledge as TCE, whereas it is closer in spirit to LCE. The perception that LCE means learners do all the work and the teacher sits back and only listens to what learners bring up is a misconception. In LCE the teacher is still expected to play his/her role as a teacher. According to Brophy (1996, p. 122) there is a stage in the implementation of LCE where the teacher is expected to introduce new concepts. This comes after the learners have been given the opportunity to wrestle with various possible explanations of these concepts.

Teacher A believes that LCE develops learners’ personal interest towards any subject and it also develops their communication skills. This is supported by Brophy (1996, p. 118) who says what the learner already knows drives what he/she pays attention to and determines how the new knowledge is understood. Through communication teachers get to understand their learners’ ideas, thoughts, misconceptions, etc. Moreover, communication facilitates the development of respect and tolerance among learners. Teacher A cited the attitude of her colleagues as the biggest challenge. It is indeed difficult to work with teachers who still cling to traditional TCE practices. These teachers measure success in terms of “notebooks accumulated and content learned as measured by examination standards rather than in terms of learners’ achieving levels of problem-solving” (Olson, 1992, p. 60). Teacher A’s main challenge was that she had not yet reached a consensus with her colleagues with regard
to classroom arrangement. Her colleagues with whom she shared classrooms still preferred the traditional way of arranging classrooms. This meant she had to rearrange her classrooms every day to suit her LCE teaching approach. A lack of resources was the other challenge identified by teacher A. Teachers are heavily dependent on textbooks and learners’ exercise books as the main teaching and learning aids. These are often inadequate and do not support a LCE approach. This deficiency can delay the entire teaching and learning reform process.

Teacher B’s main concern with regard to the implementation of LCE was time. She felt that the mathematics curriculum contains too much content which has to be covered within a limited period of time. Implementing LCE, which according to her is time-consuming, would therefore disadvantage the learners. Teacher B’s concern implied that certain ministerial policies hindered the implementation of LCE. The Mathematics curriculum, examinations and the type of examination questions that learners are exposed to sometimes compel teachers to resort to a TCA.

The discrepancies in the participants’ practices can be attributed to the different values that they hold and their diverse experiences in learning and teaching Mathematics. As stated by Fosnot (1996, p. 94), “values in mathematics education are the deep affective qualities that education fosters through the school subject of mathematics. They appear to survive longer in people’s memories than does conceptual and procedural knowledge, which unless regulated tends to fade.”

**Conclusion**

This study has shown that the assumption that teachers fail to implement LCE due to a lack of understanding is not true. The participants involved in this study knew what was expected of them in LCE but were inhibited by a range of factors from putting their theoretical knowledge into practice.

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This chapter reports on a case study conducted in three secondary schools in Rundu exploring critical reflective teaching and how it shaped classroom practice. The three participating teachers were selected because of their reputation amongst their peers as being successful and exemplary. The results of this study showed that critical reflective teaching enabled teachers to think about their strengths and weaknesses in order to improve their teaching. It encouraged them to consider and discover alternative teaching approaches. The findings also showed that as critical reflection encourages careful analysis of one’s own teaching it assists with meaningful lesson planning to mitigate the shortcomings of the previous lesson.

Introduction

This study aimed to investigate three Mathematics teachers’ critical reflective practice and to discover what effect critical reflection had on their teaching. Van Harmelen (2006) defined reflective practice as an effort and commitment to improve practice. She emphasised that critical reflectiveness is practice-oriented whereby a teacher learns-by-doing, especially in the process of implementing a learner-centred education policy. The hypothesis is that critical reflective teaching practice enhances effective teaching and learning as teachers think about what they teach and how they teach.

The reformed Namibian education policy, which replaced the “Bantu Education” curriculum, expects teachers to be well prepared to execute teaching as envisaged by the ‘Toward education for all’ policy of 1993 (Namibia. Ministry of Education and Culture, 1993). According to Lloyd
(2007) the implementation of a revised curriculum requires a change in teachers’ beliefs. Teachers have the responsibility of carrying out critical observations on their lessons and reflecting on them to identify any problems they encountered. Through effective instructional strategies, all learners’ academic performance could improve. Skovsmose (1994) argues however that too many Mathematics teachers focus on the development of mathematical proficiency, rather than reflecting on their own practice to improve teaching and learning. This argument is central to the rationale of this study.

The curriculum guide for formal basic education indicates that “[t]he emphasis in delivering the curriculum is on the quality and meaningfulness of learning” (Namibia. Ministry of Basic Education, Sport and Culture, 1996, p. 23). As the approach to teaching and learning should be learner-centred, a teacher needs to be constantly critically reflective in order to evaluate his/her own teaching. Teacher reflection has an important role to play in implementing a learner-centred approach to teaching. Dewey, cited in Rodgers (2002), Johnston-Wilder, et al. (1999, 2006), Ball, Lubienski & Mewborn (2001); Schon, cited in Van Harmelen, Taghilou (2007) and the National Institute for Educational Development in Namibia (1999), amongst others, stressed the importance of critical reflective practice in improving teaching and learning.

Research in Namibia found that teachers improved their practice through critical reflection (Hamunyela, cited in the report of the Ministry of Education & Culture, 2004). Mbango’s (2007) research focussed on the important role portfolios play in developing reflective practice. Her findings suggest that there is a profound lack of understanding amongst student teachers regarding the concept of reflective practice. Research conducted internationally by Stinson, Bidwell, Jett, Powell and Thurman (2007), Rarieya (2005) and Yoo (2001) emphasise that teaching practice can be improved through critical reflection.

**Aims of the research**

This research project thus aimed to investigate three Mathematics teachers’ critical reflective practices. The intention was to find out how the three selected Mathematics teachers use critical reflection in their classroom practice and how it shaped their teaching.
Literature review

Critical reflection is integral to life-long learning. Kilpatrick, Swafford and Findell (2001, p. 385) advocated that ongoing learning is central to proficient teaching.

Kincheloe and Steinberg (1997) suggested that problems occur when a teacher does not take a step back out of his/her teaching practice to analyse it. Teachers should not merely accept views from authorities in education or curriculum planners without critically analysing them. In relation to Mathematics, teachers need to think critically about their views on Mathematics, the content being taught, and the values and attitudes they bring to the learning environment. Prawat (1991) emphasised that the purpose of teacher empowerment is to prepare teachers to get involved in the process of bringing about adjustments in curriculum as opposed to a mere implementation of ideas. This is impossible until teachers begin to reflect critically on pedagogical aspects through what Prawat (1991) referred to as ‘an agenda’. According to Prawat (1991), teachers ought to have conversations with the ‘self’ through analysing everything they do in the classroom as teachers; and with ‘settings’ focussing on the teaching/learning environment in terms of resources and support needed by the teacher. Prawat (1991) further advocated that teachers ought to think about knowledge and value claims they regard as valid; and think about what they have to contribute to the development of the Mathematics curriculum. It is also the teachers’ responsibility to think about what to focus on in the teaching or learning environment. This is possible through a careful selection of resources and teaching approaches that enhance quality teaching and learning. Prawat (1991) further emphasised that this requires teachers to re-examine the traditional views of learning in their subject and apply appropriate theories and techniques in the learning context.

In seeking to develop practice, Dewey, cited in Arthur, Miller, Thibado, Rule, Dunham and Stoker (2007, p. 43) stressed that reflective thinking frees us from “impulsive” and routine activity. He emphasized that it enables the development of an increased awareness of individual teacher’s own pedagogy, instructional decisions they make; at the same time realizing that the choices that are made have an impact on the learning in the classroom. In addition, critical reflective practice promotes change and reflective thinking to clarify teachers’ thinking with respect to what they do as Mathematics teachers.
Proponents of critical reflection claim that critical reflective practitioners ought to exercise a democratic leadership style. The principle underpinning this argument is that a democratic leadership style requires teachers to have their lessons open for scrutiny by other teachers and learners. Dewey, cited in Arthur, et al. (2007) pointed out that reflective thinking is a process whereby teachers look back on an experience to analyse it. This means that teaching practices are critically examined from a personal perspective and from the perspective of others. He further stated that it involved thinking carefully about preferred teaching approaches during and throughout the planning and teaching process. Furthermore, Taghilou (2007, p. 90) indicates that “reflective pedagogy is an attempt to understand the learner, the teacher and the learning/teaching process as a whole; and help the pupils move toward … perfect … competency … [In addition,] reflective teaching is a means of professional development that begins in the classroom … It is a cyclical process leading to the construction of meaning”. This occurs by:

1. observing and gathering information,
2. analysing the information to identify any implications,
3. hypothesizing to explain the events and guide further action,
4. and implementing an action plan.
(Richards & Lockhart, cited in Taghilou, 2007, p. 91)

In addition, Harrison, Lawson and Wortley (2005, p. 272) said that, “[c]ritical reflection is a more detailed personal record of what has been learnt (thought) and trying out what has been learnt (action)”. Liston and Zeicher (1996) argued that for teachers to reflect critically on their Mathematics teaching practice it is imperative that they analyse their teaching in terms of four arenas/levels of reflection. These are:

- Reflection on own knowledge,
- Core values/beliefs,
- Own experience,
- Own pedagogy/teaching practice.

I included a fifth arena which I termed:

- Critical reflective teaching

**Reflection of own knowledge**
A teacher should have a sound conceptual understanding of the mathematical content he/she is teaching. A teacher is more confident
teaching Mathematics when s/he has a thorough understanding of the mathematical content and how to teach it. Elbaz, as cited in Liston (1996, p. 35) emphasised that the “practical knowledge of teachers is concerned with knowledge of self as the teacher, of the milieu or context of teaching, of subject matter, curriculum development, and instruction”.

**Reflection on core values/beliefs**
Arguing from Cornbleth’s (1987) point of view, teachers need to analyse and reflect on their beliefs about teaching Mathematics because held beliefs may contradict educational democratic ideals such as equity and attempts to realize them. Gates (2001, p. 265) emphasised that “the teacher should not objectify, construct and apply fixed criteria or rules that perpetuate inequity or either maintain learners in permanent groups”. A teacher should employ strategies to enable learners to view Mathematics as a subject that is interesting, inviting, engaging and meaningful. Since teacher beliefs are a basis for their thoughts and actions, it is important that these beliefs are appropriate and relevant (Funk, 2000). For example, if a teacher believes that girls cannot do mathematics or only the gifted learners can succeed in Mathematics, then this teacher will find it difficult to make an effort to assist girls or slow learners to succeed. Consequently, girls or slow learners’ performance in Mathematics could decline and they could develop a negative perception of mathematics. Therefore teachers ought to think critically about how their actions, guided by their beliefs, affect the learners and the learning process in the classroom.

**Reflection on own experience**
It is necessary that teachers look back at their own mathematical teaching experience and review it with the purpose of using past actions to improve future practice. According to Kolb, cited in Harrison, et al. (2005, p. 272), the experience should be scrutinised through interrogation, asking questions such as:

- What happened? And why?
- What was expected to happen?
- What does it mean?

**Reflection on own pedagogy/teaching practice**
During the process of reflection teachers ought to be critical about every aspect of the lesson to enhance mathematical proficiency. They need to
plan their lessons carefully and think about selecting appropriate and quality learning resource materials.

Kilpatrick, et al. (2001, p. 116) suggest that proficient teaching comprises five intertwined strands:

- Conceptual understanding – comprehension of mathematical concepts, operations, and relations
- Procedural fluency – skill in carrying out procedures flexibly, accurately, efficiently, and appropriately
- Strategic competence – ability to formulate, represent, and solve mathematical problems
- Adaptive reasoning – capacity for logical thought, reflection, explanation, and justification
- Productive disposition – habitual inclination to see Mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy.

Teachers should be mindful of those strands in their reflections about their own teaching.

Harrison, et al. (2005) cited Macintyre on the importance of reflecting on the technical aspects of teaching. This is important because teaching has a direct impact on the kind of learning taking place in the classroom. As the kind of teaching taking place in the classroom can either facilitate the acquisition of knowledge through construction or can impede the learning process, Gates (2001, p. 273) outlined the importance of the use of practical equipment as indicated below. To:

- provide learners with concrete experiences, something to physically manipulate, to construct understanding of abstract concepts;
- offer pupils a focus of interest and provide a richness beyond verbal and written communication;
- create an image which learners can at a later time revisit in order to reconstruct knowledge;
- demonstrate that Mathematics is a creative subject which exists beyond the pages of a textbook;
- provide imaginative approaches to learning mathematics and create, for pupils, an investment in mathematics.

Research methodology

This research is a case study specifically bound by the practice of three Mathematics teachers in their classroom situation. Three teachers were interviewed to gain insight into the use of critical reflective teaching in
their mathematics teaching process. The three participants, one female and two male teachers, were full-time Mathematics teachers who were in their mid-thirties to forty. The sample included an ordinary teacher, a Mathematics head of department and a school principal, who was also a Mathematics teacher at that time. All of them spoke English as their second language and had more than 4 years of teaching experience. Schools were conveniently selected considering accessibility to the researcher. Trust between the researcher and the participants emerged from a good working relationship between both parties that resulted from cluster teachers’ Mathematics workshops held previously in Rundu.

Data was collected through interviews and document analysis. Initially the plan was to work and engage with these teachers for a 6-month period but this was impossible due to time constraints. After an initial pilot interview with a non-participating teacher, the participants were interviewed once.

Findings

The findings of this study were grouped according to five arenas of reflection as outlined above:

Received knowledge and training
All three participants were trained as Mathematics teachers at tertiary level.

Core values/beliefs
Mrs Mula believed that learners’ performance is driven by their interest in the subject, while boredom affects attention making mathematics more challenging to the learners. She believed that planning a Mathematics lesson is not an easy exercise because one should explore effective teaching methods that could enhance mathematical understanding. She stressed that a teacher should not present a new topic before learners had mastered the previous topic. She emphasised the importance of a teacher reflecting on their work to enable learners to connect the known to the unknown mathematical knowledge.

Teacher interest and enjoyment in teaching the subject, parental involvement, understanding learners, good performance, patience, and collaboration with more experienced Mathematics teachers are some of Mr Patrick’s beliefs that contribute to learners’ success in school. He believed practical tasks facilitate learning and it is the teacher’s responsibility to enhance mathematical understanding in class but learners
should also be actively engaged in mathematics activities. He also believed Mathematics is a gateway to being open-minded because it is what a person does and it is an everyday activity. He stressed that teachers should encourage learners and help learners believe that Mathematics is an easy subject.

Mr Tadi was of the opinion that learners learn Mathematics more effectively when they are involved in activities and when they are given meaningful homework to do and learn. He believed that when teaching Mathematics, the teacher should be highly involved in helping learners solving mathematical problems on their own. He further believed that a teacher must know his/her learners’ ability in order to give them the appropriate contextualised activities and assistance. For him poor performance in learners serves as an indicator that more effort is required from the teacher. He also believed that teachers should collaborate and plan together. He said teachers should set a good example for learners to emulate. Parents should also be involved with their children’s progress.

**Experiences as a learner**

Mrs Mula reflected that she had very good Mathematics teachers at school that inspired her to do well in Mathematics. She stressed that her current teaching practice was shaped by her experience with her own teacher and she tries to emulate her previous Mathematics teacher’s teaching method to enhance understanding. Mr Patrick suggested that he understood Mathematics better when he was at the College of Education. At school his teacher convinced him that Mathematics is not a difficult subject as long as a learner is committed and practises a lot. As a result, he teaches in a similar way. Mr Tadi’s primary school teacher motivated him through competitions and incentives. He was also motivated by community members to study hard for there were no mathematicians in the area he grew up in.

**Teaching practice**

Mrs Mula indicated she teaches her learners in the same manner her university lecturers approached Mathematics, through linking classroom mathematics to real life situations. Mr Patrick teaches Mathematics according to basic principles as these help to understand the world. He tries to bring real life situations to class to facilitate learning. He plans group activities for learners to explore particular topics and it is through these activities that he assesses learners’ understanding during the lesson to determine their progress.
When teaching, he begins with easy tasks moving towards more challenging ones. **Mr Tadi** makes mathematical understanding easier through accessible methods and practical tasks. He instructs fast learners to assist others and gives slow learners more challenging work on the same topic. When teaching, he refers to the use of Mathematics in real life situations. **Mr Tadi** uses materials such as cool drink cans, computers and laptops, textbooks and books from the local library in his teaching.

Evaluation of his lessons is done through posing questions to learners, through homework and topic tests. Learners’ good performance serves as an indicator of a successful lesson. He reflects together with the learners at the end of the period where he asks, “Where did we go wrong?” Another way he tries to improve his teaching is by analysing the Mathematics examiner’s report, that outlines learners’ errors in Mathematics exams, to guide his mathematics teaching practice. He said he often reflects in his diary and on the lesson plan.

**Critical reflective teaching in general**

The findings indicate that all three teachers reflect before the lesson, during the lesson and after the lesson in some form or another. Before the lessons all three teachers think about what they are going to teach and plan accordingly.

**Mrs Mula** thinks of how to bring reality into the classroom and link mathematics content to real life with the intention of designing practical examples. This enables her to make Mathematics fun for the learners and to link new knowledge to learners’ existing knowledge. She also reflects on Mathematics content and alternative teaching methods to employ to enhance understanding and interest in her classroom. She thinks of how to connect the known to the unknown and giving real life examples such as cars driving at high speed. In her opinion teaching in this way avoids boredom among learners, because learners are good at what they are interested in and mathematics becomes easy to learn. When planning a lesson **Mr Patrick** considers the following aspects: mathematics content in terms of how to introduce it in a stimulating way, how interesting the activity will be, learners’ ability and how to accommodate learners with different levels of understanding, his role in terms of what he will carry out during the lesson, whether the planned lesson would be sufficient for the forty-minute lesson duration, designing balanced tasks beginning with easy questions leading to challenging ones, how to give clear instructions, how to manage the class to maintain discipline, his past experience as a teacher and as a learner, and how to conclude the lesson. When planning,
Mr Tadi reflects on resources to use in class, how to identify problematic learning areas and how to assist slow learners, what teaching strategies to use, learners’ results, discipline, teacher conduct, time management and Mathematics content knowledge. He thinks of preparing more practical tasks for learners to do in class.

During the lesson Mrs Mula reflects on learners’ understanding of the topic discussed through checking learners’ work while they are busy with a task. Through this she is able to detect common errors and be prepared to offer assistance through corrective feedback. During the lesson, Mr Patrick creates an environment of inquiry and invites questions based on the topic covered, gives homework, tests, individual class work and uses class discussions to identify learners’ problems. He reflects on learners’ performance and attitudes towards Mathematics. When learners do not perform well in a test or classroom activity he thinks of what has happened and how to improve on it. He thus plans to motivate learners to develop a positive attitude towards Mathematics for the sake of good performance. In addition, he motivates learners to commit themselves to their schoolwork. During the lesson Mr Tadi attempts to facilitate understanding and save time using computers and laptops. Materials such as cool drink cans are used to teach circumference and diameter for understanding. He tries to enhance understanding through the discussion of real life examples. He reflects on his own teaching, thinking about whether he is doing his work correctly. He gives homework and tests to assess learners’ performance.

After the lesson Mrs Mula reflects on the lesson objectives to determine whether the lesson objective was met or not. She reflects on learners’ understanding and progress during the lesson or teaching process. She considers her pace of teaching, the appropriateness of the teaching method used and the scope of work. If the homework given is done correctly, she feels she has met her objective. If the lesson objective is not met then she plans to repeat it the next day. Reflection informs her planning whether to proceed with a new topic or not. Mr Patrick reflects after the lesson by analysing whether he has done his work as expected. He thinks of the effectiveness of the lesson with regard to how he explained a specific topic - whether it was clear to the learners or not.

Mr Tadi’s reflection after the lesson looks at what happened and where he went wrong during the lesson. This helps him to build on his strengths by working on his weaknesses through planning differently. He feels if learners pass a test or task given in class then the lesson was successful.
Conclusion

The results of this study revealed that participants reflected richly and deeply about their teaching. The interviews revealed that the three teachers engage in what Hall, cited in Van Harmelen (2006) referred to as ‘deliberate and systematic reflection’. The participants indicated that they reflect before the lesson (when planning), during the lesson (when teaching) and after the lesson (when teaching is over). According to the teachers, critical reflective teaching transforms classroom practice. They defined critical reflection as being conscious of learners’ progress to evaluate their own teaching practice as teachers. It is also a process of being conscious of what they teach, how they teach and whether they teach as expected. They pointed out that critical reflection enables teachers to find alternative approaches to teaching, which may enhance the learning of mathematics with understanding. In addition, they stated that critical reflection also helps to anticipate the impact of instruction on learners’ understanding. Furthermore, they emphasised that critical reflection enables them to decide whether to proceed with a new lesson or not. Evidence of reflection in the three teachers was verified in their lesson plans. A strong theme that emerged was that critical reflection directs planning in terms of future actions to execute.

REFERENCES


THEME 3

BROADER CLASSROOM PRACTICE
This chapter reports on an investigation of the prevalence and nature of code switching practices in Grade 8 Mathematics classrooms in the Ohangwena region of Namibia. The prevalence of code switching practices in these classrooms was established by administering a survey to all Grade 8 teachers in the region, while the nature of these practices was explored by interviewing and observing selected teachers using a case study research methodology. The study found that code switching is widespread in most of the Grade 8 Mathematics classrooms in the Ohangwena region. It also revealed that the teachers’ code switching practices aligned well with most of Probyn’s (2006) framework. The criterion of maintaining learner’s attention with question tags was however not found in this study. The results of the study showed that teachers code switch because the majority of the learners’ language proficiency is not good. Code switching is mostly used as a strategy to support and promote learners understanding in mathematics. The study recommends that it is high time that code switching is acknowledged as a legitimate practice and recognised as an important and meaningful teaching strategy to assist learners who are learning mathematics in their second language. Code switching needs to be de-stigmatised and teachers should be supported in using this practice effectively and efficiently.
Introduction

Namibia is a multicultural and multilingual country with the majority of the population speaking one or more of the seven African languages. A small minority speaks English and other foreign languages. After independence in 1990, English was chosen as the official language and the language of instruction in all schools. Although it is only the home language of less than 0.8% (Namibia. Ministry of Education and Culture [MEC], 1993) of the population, English was chosen because of social, economic and political reasons (Probyn, 2006). The National Curriculum for 2010, as well as the Language policy of Namibia (Namibia. Ministry Basic Education, Sports and Culture [MBESC], 2003), stipulates that learners should learn in their mother tongue during the first 3 years of schooling. In Grade 4 the shift is made from mother tongue instruction to English as a medium of instruction. In Grades 5-7 the medium of instruction is English with a little mother tongue support, while in Grades 8-12 the medium of instruction is entirely in English. The rationale of the policy is that by the end of their seven years of schooling learners will be sufficiently linguistically proficient to be able to handle the demands of the various school subjects’ content in English (Namibia. Ministry of Education [MOE], 2009). However, this is not always the case. There is a widespread perception that learners come to the secondary school phase (Grade 8) with poor proficiency in English.

Looking at the results of the national standardised tests carried out in Grades 5-7 in English, Mathematics and Science, the Namibian learners are performing poorly, particularly in English and Mathematics (Sasman, 2011). This is one of the reasons that by the time they enter Grade 8 learners are not adequately equipped to handle the subject content in English as intended. It is asserted that an inadequate command of English is one of the major factors attributed to the poor performance in Mathematics in the Grades 10 and 12 national examinations (Wolfaardt, 2005). The examiner reports regularly comment on this issue (Wolfaardt, 2005). This, in my view, is a clear indication that language plays a major role as one of the barriers to the teaching and learning of Mathematics in Namibia. Mathematics teachers are faced with the interesting challenge of teaching both language and mathematics content (Setati, 1998). Bose and Choudhury (2010) express the view that language plays a vital role in thinking, learning and teaching. The role of Mathematics teachers in Namibia is thus a complex one as they are expected to devise innovative teaching activities and make use of effective teaching strategies in a
context that demands high quality content teaching, and at the same time be sensitive to multilingual dynamics. In multilingual schools and classrooms in Namibia where learners and teachers share a common mother tongue, it is likely that communication will occur in both English and mother tongue – a practice known as code switching.

**Aim of the research and research questions**

The aim of the study was to investigate the prevalence and nature of code switching practices in Grade 8 Mathematics classrooms in the Ohangwena Region of Namibia. In order to do this the following research questions were asked:

1. What is the prevalence of code switching practices in all Grade 8 Mathematics classes in the Ohangwena Region of Namibia?
2. What is the nature of these code switching practices in selected Grade 8 Mathematics classrooms in this region?

**Literature review**

According to Setati (1998) code switching is the use of more than one language in a single speech in a multilingual context. Planas and Setati (2009) refer to the use of two languages in Mathematics as language alternation. According to Brice and Roseberry-McKibbin (2001) language alternation can be divided into two linguistic categories of code mixing (alternation across sentences) and code switching (alternation within sentences).

Studies in multilingual and bilingual schools (Uys, 2010) revealed that code switching is a common practice, particularly in a situation where the language of instruction is a second or a third language of the learners and the teachers. In instances where teachers and learners share a common mother tongue, code switching is an inevitable practice in the classroom. In my experience, code switching is a very common practice in Namibian schools. In Namibia most learners speak very little English outside school. They mostly use their mother tongue when at home, in the school playground and in the classroom when communicating with each other.

According to researchers, code switching is used in classrooms for different purposes. Probyn (2006) noted that the teachers code switch from English to the learners’ home language for a wide range of purposes, such as:
a) To explain concepts;  
b) To clarify statements or questions;  
c) To emphasise points;  
d) To make connections with learners’ own context and experience;  
e) To maintain the learners’ attention with question tags;  
f) Classroom management and maintaining discipline;  
g) Affective purposes.

Setati (1998) further suggests that code switching occurs when there is the need to focus or regain pupils’ attention, or to clarify, enhance or reinforce lesson material. Uys’ (2010, p. 53) research finding revealed that “code switching occurred in the observed classrooms for a reason – not only for social reasons but for academic reasons and for classroom management”. Uys (2010) also found that although code switching is often stigmatised, it is widespread, even in classrooms which officially only have one language as the medium of instruction.

Despite the extensive use of code switching and its great value in the teaching of mathematics, code switching receives a lot of criticism. In Namibia it is not officially supported by education policy. Thus, those teachers who practise it often do so uneasily. Probyn (2006, p. 394) states that “it appears that many teachers still regard code switching as illicit, as a sign of failure rather than a legitimate classroom strategy.” For these reasons, teachers are less likely to use the learners’ home language when they are observed or are interacting with department officials and peers.

Language plays a major role in education and in the Mathematics classroom in particular, therefore the practice of code switching is worthy of investigation in order to contribute to the understanding of this phenomenon. It is through gaining insight into this practice that appropriate language policies can be drafted and meaningful support provided to teachers. Very little research into code switching practices has been conducted in Namibia and my study aims to contribute to the urgent conversation that needs to happen about this subject in my country.

**Research methodology**

This study consisted of two phases:

**Phase 1** consisted of a survey in which I sought to reveal the prevalence of code switching in all Grade 8 classes in the Ohangwena region. There are 106 secondary schools in this region and I sent out questionnaires to be completed by all the Grade 8 Mathematics teachers in these secondary schools.
For **Phase 2**, I adopted a case study methodology where my unit of analysis was the nature of the code switching practices of two selected Grade 8 Mathematics teachers.

**Findings**

In broad terms, the findings from the survey and observation revealed that teachers code switch mainly for performance reasons. During the survey and in the interviews, teachers did not acknowledge that they code switch for classroom management and maintaining discipline. My observations however revealed the opposite. Further, the open ended questions in the survey and interview revealed that poor language proficiency in English amongst learners is another reason why teachers code switch.

The survey results showed that on average teachers code switch between 1 and 5 minutes or between 5 and 10 minutes in a 40 minute lesson. It could be argued that this is not excessive, but many teachers disagreed with this and thought that any code switching promotes laziness in learning English and a dependence from the learners’ perspective that concepts would always be translated into mother tongue.

The study showed that the two participating teachers were fully aware of the language policy and what is expected of them at this grade. These teachers, however, choose to code switch because they believed that the practice benefits the learners.

By far the majority of the teachers in this study, around 95%, speak Oshiwambo as their home language. This is the same language that their learners speak. The survey shows that 70% of teachers and 95% of learners mostly speak Oshiwambo outside the classroom. 77% of the teachers said that the children use Oshiwambo when speaking to each other in the classroom. This clearly shows that the Oshiwambo language is mostly used at school with little exposure to the English language. Looking at the dominance of Oshiwambo in schools, the use of code switching seems to be inevitable in such schools. The survey also indicates that teachers code switch mostly for performance reasons, viz. to explain concepts and explain procedures, and to clarify statements and to emphasize points. Other uses of code switching relate to classroom management and discipline, making connections with learners’ own context, maintaining learners’ attention with question tags, and for affective purposes.

Consistent with the findings of the survey, the observed lessons of the two teachers revealed that code switching is used mostly when explaining
and clarifying concepts and procedures. This relates to improving the performance of the learners. Contrary to the survey findings however, the observations also revealed that the participating teachers made extensive use of code switching for classroom management and discipline purposes. In the lessons observed no examples were found of using code switching to maintain the learners’ attention with questions tags. The survey indicated that 69% of the respondents report that they code switch for 5 minutes or less in an average 40 minute lesson. 28% indicated spending between 5-10 minutes on code switching. Only 1% indicated 10-15 minutes and 2% indicated 15-20 minutes. The survey revealed that 57% of the teachers felt that code switching practices help to improve the learners’ performance in mathematics; while 43% of the group surveyed did not believe that code switching helps in improving the learners’ performance.

Those teachers who believe that code switching helps improve the learners’ performance in Mathematics believe that code switching is a good practice for the following reasons:

- it helps learners understand the subject,
- it helps in the explanation of concepts and methods,
- it helps learners with a poor English language background,
- it helps learners to remember the concepts that they have already learned, and
- it helps to accommodate all learners with different learning abilities.

Those teachers who feel that code switching does not improve the learners’ performance in Mathematics argued that the Mathematics textbooks, question papers, examinations, tests and activities are always written in English, therefore the learners must be competent in English for assessment purposes. They also argue that code switching is not a good practice as it does not align with policy. Further, they say that code switching promotes laziness and dependence among learners. It does not improve the learners’ communication, but causes a lack of understanding of exam questions. They argue that because English is the medium of instruction, teachers must teach in English across the curriculum.

In applying Probyn’s categories to the data I found that there was no category that captured ‘explaining procedures’, yet this was a frequent occurrence where code switching occurred in my study. I thus added another element to Probyn’s first category, viz ‘Code switching to explain concepts’.
In terms of patterns of code switching across a lesson, it was notable that one of the teachers code switched more at the beginning of the lesson where new concepts were being introduced. This teacher used less and less code switching as the lesson progressed. The same applied to his learners. This indicates that code switching is useful to assist the learners’ understanding until they become familiar with the concepts and procedures. Thereafter both the teachers and learners went back to using the medium of instruction (English).

The two teachers that I observed were fully aware of the language policy, particularly as it applied to the grades they were teaching. They claimed they code switch mostly when they believe that that their learners needed clarification of content and to attract the learners’ attention. In their opinion code switching helps learners who are not very proficient in English. They also argued that code switching helps improve learners’ participation and their performance. The two teachers felt that parents and the Ministry are not aware of the prevalence of code switching practices in schools. The issue of code switching was never discussed with parents of their school. They also said that the Ministry had never sent anyone to observe their lessons or advise on code switching practices. Both teachers challenged the official language policy and felt a revision of this policy should be considered.

**Conclusion**

The findings revealed that the practice of code switching is common in the Ohangwena region of Namibia and this finding answered my first research question. To answer my second research question, the results revealed that the nature of code switching is multi-faceted. Teachers code switch for different reasons and purposes. The teachers indicated that they code switched because the learners’ language proficiency in English is poor and that they wanted to promote the performance and participation of their learners. My findings align very well with those noted by Probyn (2006) and I make the following recommendations:

- In the context of poor language proficiency in English across the entire spectrum of learners, code switching is a legitimate and effective means for teaching and learning. The use of code switching can be a very effective strategy to bridge Mathematics content, the English language and the mother tongue.
There is a need for teachers to read and understand the language policy.

The learners’ home language should be used properly in the early school grades (Grades 1-3) as the policy stipulates because this helps in the acquisition of the second language. The policy should however allow for code switching to be used beyond Grade 7 where necessary to aid in the teaching and learning process. This would legitimize code switching and teachers would not feel stigmatized and ill at ease.

There is a need that issues of language in general, and code switching in particular, should be discussed and debated openly and widely. Teachers should be consulted and brought into the discussion arena. This should also apply to parents.

The Ministry of Education and its policy makers should recognize the value of code switching and consider its inclusion in the language policy at all levels.

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A serious challenge in Namibian education reform, particularly in sparsely populated rural areas, is the need to teach multigrade classes. Many of these classes have arisen due to improved access to education. Multigrade teaching is a difficult practice and Namibian teachers are not well prepared to teach these classes. This research was a case study focussing on the teaching of Mathematics in multigrade classrooms. It was found that the Mathematics curriculum was not well suited to multigrade teaching and that teachers had received no explicit training for such teaching, needing to learn effective approaches through trial and error. Nevertheless, some effective teaching of Mathematics was noted in these classes. The teachers in the study generally followed a quasi-monograde approach to teaching, where each grade group worked on different learning tasks and teachers took turns to teach each grade group.

Introduction

Namibia reformed her education policy after independence and shifted from “education for elite” to “education for all” (Namibia. MEC, 1993, p. 2). The Namibian education system is challenged by the provision of quality education, particularly the quality teaching of Mathematics to learners in sparsely populated and remote areas (Namibia. MBESC, 1996). In these areas, learners are few in number and they are therefore taught in combined grades. “Multigrade teaching” is the standard international term used for such a combination of grades (Birch & Lally, 1995, p. 1). Multigrade teaching is an important concern in Namibian education and it is receiving special attention from the Ministry of
Education. The practise is followed in order to provide accessible and high quality education to all children regardless their age, culture, gender or race (Namibia. MBESC, 1996).

Although multigrade classes existed in the Namibian education system, there were no materials to assist and guide teachers in teaching these classes. Based on this, a committee was established at NIED tasked with developing a multigrade teaching manual (Namibia. MoE, 2007a) and a multigrade teachers’ guide (Namibia. MoE, 2007b) which could effectively assist teachers of multigrade classes.

Many studies of multigrade teaching and learning have focused on factors influencing learners’ performance in multigrade settings (Veenman, 1995; Veenman, 1996; Russell, Rowe & Hill, 1998). Others have researched the differences between teaching in mono-grade and multigrade classrooms (Little, 1996). In Namibia, very few studies have been conducted on multigrade teaching. Titus (2004) examined the management and leadership challenges that face principals in multigrade schools, while Beukes (2006) investigated the views and perceptions of multigrade class teachers in Namibia. She also investigated the teaching of Mathematics in schools that follow the different ungraded system. However, none of these researchers studied the teaching of Mathematics at the upper primary phase. This study investigated how Mathematics is taught in upper primary multigrade classrooms in Namibia, focussing in particular on teachers’ practice of teaching Mathematics in these settings.

**Aims of the research**

The study investigated teacher practice in upper primary multigrade classrooms in Namibia, considering possible good practices and challenges that may occur.

In particular, it investigated:

- teaching strategies that teachers use to teach Mathematics in multigrade classrooms;
- the extent of assistance given to multigrade teachers by colleagues at their schools, clusters, circuits and regions; and
- possible good practices for multigrade teaching of Mathematics.

**Literature Review**

Multigrade teaching relates to the teaching of learners of different grades and abilities by a single teacher in a single classroom or group (Birch &
This should not be confused with teaching multi-age groups, where children of different ages are grouped together for educational and pedagogical benefits. The following definition of multigrade teaching will be used in this study: “two or more grades are taught simultaneously” (Little, 1995, p. 17).

Multigrade teaching is often an approach followed to cope with declining student enrolment or uneven class sizes (Veenman, 1996). A UNESCO/APEID study cited in Little (2004, p. 10) identifies a number of benefits of multigrade teaching, which include: learners development of self-study skills; learner cooperation across age groups resulting in collective ethics, concern and responsibility; learners’ helping each other; and the capacity for teachers to organise both remediation and enrichment activities for low and high achievers respectively more discreetly than in monograde classes. Younger children are also believed to learn more quickly from older learners in multigrade classes (Namibia. MoE, 2007a). This can help learners in lower grades to cope with their work for the upcoming year.

The Namibian curriculum assumes multigrade teaching to be the norm in small schools, but it opposes the combination of three grades as well as the combination of Grade 1 with other grades (Namibia. MBESC, 1996). However, what generally happens in reality is the combination of Grades 1 and 2; 3 and 4; 5 and 6; as well as 6 and 7. In some cases, the combination can consist of three grades and, in the case where the school has no other alternative, all the Lower Primary grades or all Primary grades (Grades 1 to 7) are combined. This study focused on combined grades at the upper primary level.

There are various strategies which one can use in teaching Mathematics. One of these is whole class teaching (Miller, 1991) which is commonly used in many classrooms. In addition to this, Little (2004) noted four curriculum adaptation strategies that are effective for multigrade classrooms. These are: Multi-year curriculum spans which spread the units of curriculum content across two to three grades rather than one, and require learners to do common topics and activities; differentiated curricula which cover the same general topic or theme with all learners and allow them to be engaged in learning tasks appropriate to their level of learning; quasi monograde teaching where a teacher takes turns in teaching each grade group as if they were monograded (the distribution of time between grade groups depends on the particular tasks of each group); and learner and materials-centred teaching which is heavily reliant on the learner and learning materials, rather than on the
teacher’s input – a strategy that translates the curriculum into graded, self-
study learning guides and allows learners to work at their own speed with
support from the teacher and structured assessment tasks.

Cash (2000) also identified a number of popular strategies for
multigrade teaching that are also suitable for the teaching of Mathematics. These include:

- Individual work cards or workbooks – instructional or problem
based cards written out with the content to be taught in the
specific lesson or topic.
- Holding activities, in which children who are not in direct
communication with the teacher are given something to do.
- The staggered approach, where the teacher teaches the first group
of learners and gives them an activity before he/she starts
teaching the second group and the teacher keeps on shifting his/
her attention depending on the need of the individual class
groups or learners. differentiated direct teaching, where the aim
of the lesson is explained and the work is introduced through
direct teaching with examples. Here the learners are involved
through questioning and they are given the chance to practice the
use of the concepts introduced, while the teacher visits
individuals or groups to facilitate learning.

These approaches can be used with various teaching strategies in
multigrade classrooms such as individual learning, whole class teaching,
small group teaching, peer group teaching and self study. Little (1995)
sees the last two as the mostly associated with multigrade teaching.

Most Namibian schools seemed to follow the quasi monograde system
with a common timetable. This may have resulted from a lack of teaching
and learning materials, the lack of training of multigrade teachers, the
grade specific syllabus and the arrangement of basic competencies in the
Mathematics curriculum, or the monograde timetables which are set in
most schools.

Methodology

This study followed the interpretative paradigm, because of the interest in
understanding teachers’ experience in their classroom practice. Purposeful and convenient sampling was used to select four schools with
multigrade upper primary classes, on the basis of their location and type.
These schools included an urban, semi-urban, rural and semi-rural school
in the Khomas, Hardap and Omaheke regions. Convenience played a role in their selection because these regions were chosen due to proximity to the researcher’s place of work. The study participants were Mathematics upper primary (Grade 5-7) multigrade teachers (one teacher per school) with two or more year’s experience.

The research followed a case study method – “a form of qualitative research focused on providing a detailed account of one or more cases” (Johnson & Christensen, 2004, p. 46). In order to compare and contrast the teaching of Mathematics in multigrade classrooms, I conducted four case studies (one for each teacher), using multiple sources of data (Anderson, 2000) including interviews, document analysis and observations in the settings (Punch, 2005) of the multigrade classrooms.

One individual interview, 40 minutes to 1 hour in length, was conducted with each participant. Before the interview, a one page questionnaire was used to collect basic information about each participant. An interview checklist with open-ended questions was designed and refined after being piloted with the Mathematics teacher in a different multigrade school. The refined checklist was then used to guide the interviews (Johnson & Christensen, 2004). These interviews focused on teachers’ experiences in areas such as classroom management, planning and instructional strategies, designing of instructional materials, involvement of the whole school and community in multigrade teaching, as well as the teachers’ views of challenges and opportunities for multigrade teaching.

One classroom observation was conducted for each participant, to obtain information regarding the teachers’ practices in multigrade classes. The lessons were videotaped, allowing the researcher to later review and analyse the observed lessons. The focus of the observations was on teachers’ classroom practice such as management, arrangement, and handling of two or more grades, as well as instructional strategies. I was a non-participant observer, detached from the activities that were taking place during the lessons (Anderson, 2000; Cohen, et al., 2007).

Documents were used in this study to supplement the data collected through interviews and lesson observations. These were: the teachers’ preparation notes and the notes written on the chalkboard. The researcher also maintained a research record that contained written comments relating to each teacher’s practice.

Both the tape recording of the interview and the videotaped lessons were transcribed. The data gathered through interviews, observations and document reviews were then organised, categorised and analysed in order
to discover the commonalities, differences and similarities. In order to report this data, a narrative description method was carried out in chronological order. Two levels of analysis were conducted. In the first level of analysis the data was presented individually across the instruments. The data was also contrasted in the second level of analysis in order to identify possible good practice and challenges in the participants’ multigrade teaching.

Findings

There were a number of commonalities and differences in the ways the case study teachers taught multigrade mathematics classes.

Organization and infrastructure

Teachers appeared to have arranged their classrooms by considering the types of furniture, and the number of grades in a class, as well as the teaching strategy which they were using during the specific lesson. Many of these arrangements allowed learners to communicate with the teacher as well as with other learners during the lessons. The majority of classes had most learners facing the chalkboard, facilitating the extensive use of the chalkboard by the teacher for the presentation of lessons. The learners who directly faced the chalkboard also had direct eye contact with the teacher during presentations. This enabled learners to observe body language and develop interpretive skills in relation to the gestures and the signs which the teacher might use during the lesson presentation. The teacher was also able to read learners’ facial expressions which might indicate how well they were following the lesson. Finally, it allowed the teacher to easily control the whole class because he/she could see the individual learners. Two of the teachers placed their tables in front of their classrooms and the other two placed their tables at the back. The tables at the back made it necessary for learners to turn around whenever the teacher was giving instructions from his/her table. Also, having the resources on these tables far from the chalkboard was time consuming because the teacher had to walk to the table if there was something required for the presentation. Having the table in front of the classroom reduced the walking distance for the teacher.

One school had far fewer resources than the other three and it was noticeable that the lack of resources in this school negatively impacted on the teaching as the teacher spent considerable amounts of time facilitating the lending and borrowing of the limited resources between children.
Learners were also interrupted by the teacher when they were asked to assist others sharing resources, even when they were busy with classroom activities. This contributed to the difficulty the teacher experienced in completing lesson activities on time. Three teachers used their chalkboards to write summaries of the discussed topics during the lesson, ending the lesson with a well developed summary on their chalkboards. The fourth teacher had very few sentences, as she only used the chalkboard when she was explaining, but did not write a summary on it. The summary might have helped learners to review the work during their free time, but unfortunately none of the teachers encouraged learners to copy the summary.

The teachers appeared to use the back and forth (Lataille-Démoré, 2007) method of moving between the two grades. They also appeared to use the basic competencies for the lowest grade and extended these to cater for the higher grade. If the topics to be taught were the same for the two grades, teachers appeared to compare the content of the grades to see if there were similarities or differences in the subject matter. If there were, they informed the learners in different grade groups. Their teaching of the same subjects with different basic competencies satisfied the common timetable approach.

Planning is a core element in the teaching of multigrade classes. The teachers recognised the importance of planning in their multigrade teaching, but only two teachers had written lesson preparation. The teachers’ planning to teach the same topic to combined grades related to the Namibian curriculum which suggested the “simultaneous teaching” of the same topics in multigrade classes (Namibia. MBESC, 1996).

All teachers had school timetables in their classes, and they confirmed that they followed the general school timetable, although teachers did deviate from the planned timetable to suit their needs. The observed lessons were longer than the usual time indicated in a timetable. Teachers also tried to balance the time equally between two grades within the allocated time of 40 minutes per lesson.

The teachers’ role in the classroom
The teachers’ role in multigrade teaching did not appear to be different from that used in mono-grade classrooms. Generally the teachers introduced and developed the lessons with the whole group and then gave learners activities to do individually, in pairs, or in small groups. By walking around, teachers could see the learning progress of their learners.
They also noticed the good work and mistakes made by the learners. The teachers used similar responses to the mistakes made by the learners. Three of the teachers reacted as follows: Once they noticed a problem amongst the learners, they corrected and assisted individual learners first before they informed and alerted the rest of the class about the same mistake. The fourth followed a different approach. If she noticed her learners making mistakes, she informed the whole class to prevent them from making the same mistake – without assisting the individual learner. The absence of enrichment activities in all classes caused discipline issues with learners who had finished earlier and had nothing left to do.

Having learners spending much of their time doing the activities individually or in pairs during the presentation indicated that some learners in these multigrade classrooms became responsible for their own learning at an early age. Most learners did not make a noise during these activities, indicating that they were effectively engaged in the work.

The teachers managed their teaching of the different grades in different ways. Shiwa taught the combined group as one, teaching the same content to all learners without differentiating between grades. She did not have learners waiting to be instructed because they were doing the same thing. Janet, Bibi and Jatty taught their combined grades separately, shifting from grade to grade depending on the group which finished or which needed attention at that time. Learners were therefore given time to complete their tasks while the teacher was involved in direct communication with the other grade or group of learners. Bibi and Jatty started with their Grade fives and the Grade six learners sat quietly waiting for the teacher while this was being done. Jatty’s Grade six learners were not attended to for a long period because she spent a lot of time giving information to the Grade five learners. Janet distributed worksheets to all grades at the same time. When she started with the Grade six learners, the Grade five learners read their worksheets. The waiting period for Janet was used very effectively because learners were busy all the time.

Teachers had different ways of introducing their lessons. Janet and Shiwa used a common activity for all grades during their introductions. All teachers revised their previous work before they started with new work. Shiwa and Janet started their lesson with all learners doing drill exercises. All of the teachers considered the multiplication table as the core of mathematical learning for their grades. They focussed explicitly on terminology during their presentations. Jatty’s and Shiwa’s learners were introduced to the terminology for fractions. They also paid a lot of
attention to procedures and strategies used to find the solutions to problems. Janet’s Grade five learners were also told to master the procedures for using the operation on expanded notation and the Grade six learners were taught to use drawing strategies to solve word problems. Bibi taught his Grade sixes the terms in multiplication and division, while his Grade five learners were taught division using one and two digit divisors. The learners took part in the lessons and finished sentences with their teachers during the presentation. They also assisted and corrected their teachers when they left out some information during the presentation.

The participants in this study used various teaching strategies to teach Mathematics in their multigrade classrooms. They all practiced the lecturing method, where they presented and explained mathematical content to their learners, as well as to clarify issues with the learners. This was then combined with various strategies such as group work, peer tutoring, and individualised learning. According to Little (1995), peer tutoring and individualised learning are the most effective teaching strategies in multigrade teaching.

The teaching approaches varied from one teacher to another. Despite the pair seating arrangement in Shiwa’s class, the lesson was presented to the full class and learners then worked individually. Bibi and Jatty had pair or group teaching, based on the question and answer method. Janet used an activity-based learning strategy with individual learners – collaboration was only used when learners marked their scripts after the warm-up activity, the rest of the lesson involved individual exercises and approaching the teacher when they had questions.

All teachers demonstrated part of the lesson during their instruction, using chalkboards or notice-boards in the cases where the teaching aid was already displayed. The relevant groups of learners were requested to look at the demonstration, for them to imitate. Jatty demonstrated how Grade five learners could find equivalent fractions by using the fraction wall. She also showed the Grade sixes how to write the fractions in symbols when given expressions in words. Janet’s demonstration to the Grade sixes indicated how to solve a word problem by drawing pictures, and the Grade five learners were shown the various steps for calculating expanded notation involving decimal numbers. Bibi demonstrated the procedure for division with two digit divisors using whole numbers to the Grade fives, and taught multiplication terminologies to the Grade six learners.
These teachers used various methods to teach their classes. Bibi and Jatty used group work and peer teaching in their lessons. Little practice of peer group work was found in these two classes. Bibi’s learners helped each other during the lesson by calculating together. He also asked them to give their answer in pairs. Jatty’s Grade five learners were motivated to show others how to find equivalent fractions on the fraction chart. However, during the interview Bibi and Janet felt that learner-centred (LCE) teaching is not suitable for multigrade teaching. These teachers seem not to understand the learner-centred approach.

Some of the teachers themselves worked with smaller groups of learners. When interviewed, they explained why they had chosen to work with or without groups. Here is an excerpt from Jatty’s interview:

The group works at the certain group. There it is easiest to work with the groups so that now I explain to five to this group and I go to that group again. I think that is more suitable to work in groups with the Grade fives and the Grade six learners and then as a whole.

Shiwa preferred to do direct teaching because she did not have time to deal with groups. Her explanation of how she teaches her combined grades was:

I do mostly direct teaching; I don’t do more individual explanation because I am already having a hard time covering the curriculum. Mostly, I am at the front giving them examples, having them do their own, walking around seeing how they are doing and then moving on to the next topic.

Janet also sees group work as time consuming. She gave the following reasons why she does not use group work:

I know it is probably against all the policies but I found group work is just a bit chaotic. The ideal group work is fine but critically I found it difficult because you normally get one person doing [all activities]. Even though you try to encourage everybody to take part, it is quite difficult.

Although Shiwa and Janet did not use grouping in their lessons, their method of individual learning also seemed to work in multigrade teaching.
Support for multigrade teaching
The teachers indicated the need for support in teaching multigrade classes. Although there are regional Advisory Teachers (AT’s) for Lower Primary schools and for various subjects from Upper Primary to the Secondary Phase, these AT’s rarely visit the multigrade schools to give assistance. Since independence, teacher support has played an important role in teaching and learning. However, none of the teachers knew about the regional initiatives of training programmes for multigrade teaching. Teachers meet regularly in cluster meetings, but they hardly discuss issues pertaining to this model. In many cases they feel isolated as there is no one to share the multigrade problems with at cluster, circuit or regional level. Janet’s school observed how new teachers suffer in multigrade teaching situations. In the same vein, Bibi and Jatty also suggested that content and syllabus knowledge could be very helpful when teaching combined grades.

In addition to that, teachers indicated the need for multigrade workshops where they could learn more about how to handle multigrade classes. Teachers also indicated that to be a good quality multigrade teacher one has to be positive and determined to overcome the difficulties. They also indicated the importance of reading more about multigrade teaching approaches. This is how Bibi explained the situation:

I try, I read about a lot of approach in multigrade. But then further I think it is together with the knowledge of that you have learned from others experience. My positive attitude about multigrade, good planning together with it and also my knowledge about the subject, I must know the subject.

Challenges facing multigrade teachers
The observed teachers appeared to have no choice in modifying the monograde materials to suit their multigrade classes, following the curriculum model identified by Birch and Lally (1995). This was done in the absence of a multigrade curriculum.

The teaching of multigrade classes is a challenge to most of the teachers because they were not trained to teach in multigrade classes. As stated by Little (2001), they learned to teach these grades by trial and error. The teachers indicated their willingness to learn more about the subject, so that they could be able to assist the learners more effectively. Bibi articulated it this way:
It is about new ideas. I always try to learn more with the multigrade teaching. We come together, talk to each other. In the cluster level, not really. That is only at subject level not in combined classes. Sometimes if it is really a problem then we discuss it and even discuss it with another principal with multigrading.

Conclusion

The study revealed that multigrade teachers mostly use their monograde pedagogical knowledge, resulting in using quasi-monograde with a common timetable approach when teaching Mathematics in multigrade settings. Although learners have access to the common Mathematics syllabus, the quality of teaching the subject in multigrade classrooms seems to be affected due to the lack of teacher training in multigrade teaching. Also, one of these multigrade schools was poorly resourced and the resulting need to share resources had a negative impact on the time spent learning mathematics in the school.

Good practice of multigrade teaching existed in building on lower grade competencies, introducing lessons with common activities, as well as the concentration on lower grades which resulted in learners becoming independent. However, insufficient time, lack of knowledge about teaching multigrade classes and lack of curriculum knowledge seemed to challenge teachers and learners. No explicit training for multigrade teaching had been provided and this made it difficult for teachers starting to teach such classes. But there was evidence of good teaching in a number of these classrooms. The participant teachers had learned through trial and error and were motivated to read and learn about multigrade teaching and were positive and committed to multigrade teaching.

REFERENCES


The purpose of this case study was to gain insight into observed discrepancies between continuous assessment and final examination average marks in Grade 10 Mathematics in the Oshikoto region of Namibia. The results of this study indicate that while continuous assessment is seen as an important component of the teaching and learning process, there are nonetheless tensions between its summative and formative value. Teachers and principals would in general welcome greater transparency, standardization and moderation of continuous assessment practice, as well as support with the setting of appropriate continuous assessment tasks.

Introduction and background context
The 1990 independence of Namibia brought about significant education reforms including, amongst other things, the reorientation of teaching and learning methods from a teacher-centred to learner-centred approach (Namibia. Ministry of Education and Culture [MEC], 1993). One of the main principles of learner-centred education [LCE] is that of continuous assessment (Kruger, 2004). Consequently, Namibia now uses two modes of assessment, formative and summative, to obtain a promotional mark for a learner working towards the Junior Secondary Certificate [JSC] at the end of their Grade 10 year. In Mathematics the continuous (formative) assessment mark [CA] and the end-of-year examination (summative
assessment) marks are combined in the ratio 7:13 under normal circumstances. This produces each learner’s national examination result that is used for promotion to the next grade (Namibia. Ministry of Education [MoE], 2006, 2010).

The policy and information guide published by the Namibian Ministry of Basic Education, Sport and Culture [MBESC] (1999) explains that when continuous assessment has been conducted as expected, the results should predict the outcome of the end-of-year examinations. Policy documents suggest that this is because “there is an overlap of objectives and competences assessed” (Namibia. MBESC, 1999, p. 11). The general assumption put forward by the policy implies that the average results of formative assessment should be a true prediction of the end-of-year examinations which are regulated and standardised by the Directorate of National Examinations and Assessment [DNEA]. This is seen to be the ideal scenario, although it is contingent on teachers in schools collecting reliable and valid information about learners’ performance in the various basic competences (Namibia. MoE, 2010, p. 10).

The current study was prompted by observed discrepancies in Grade 10 CA and end-of-year examination marks for the 62 Junior Secondary Schools in the Oshikoto region of Namibia over the period 2008-2010. Typically schools fell into one of three groups: (A) those schools whose average CA mark was higher than their average examination mark, (B) those schools with comparable average CA and examination marks, and (C) those schools whose average examination mark was higher than their average CA mark.

The problem being contextualised in this study therefore stems from personal experience as well as that of colleagues teaching Grade 10 Mathematics. There is confusion as to which of the three scenarios is preferable, or even whether a comparison of the two types of assessment, formative and summative, is meaningful (Samson & Marongwe, 2013). This background motivated an enquiry into the disparities surrounding assessment practices with a hope of finding ways of encouraging teachers to move towards a scenario that promotes fair assessment of the Namibian child (Namibia. MEC, 1993; Shilongo, 2004).

Aims of the research

The main purpose of the study was to gain insight into the discrepancies that exist between formative (CA) results and summative (end-of-year examination) results in Grade 10 Mathematics. The study attempted to
establish possible reasons for the discrepancies and hence develop a deeper understanding of the effective use of formative and summative assessment in the JSC Mathematics landscape.

The study was structured around the following research questions:

- What are the characteristics of the analysed Grade 10 CA and end-of-year examination average marks for the period 2008-2010?
- What are the teachers’ and principals’ perceptions of CA and end-of-year examinations as components of summative assessment in Grade 10 Mathematics?
- What is the relationship between the teachers’ perceptions and the observed discrepancies?

**Literature review**

Assessment can be defined as the process of finding out how learners are progressing – a measure of what learners know based on performance evidence that can be used to inform future actions (Black, 2008; Namibia. MBESC, 1999; NAS, 2011). One purpose of assessment is to facilitate communication about what learners are learning. The outcomes of assessment may also be used to promote learners to the next grade. MBESC (1999, p. 5) explains that assessment may be helpful to:

1) Diagnose learners’ strength and needs, 2) provide feedback on teaching and learning, 3) provide a basis for instructional replacement, 4) inform and guide instruction, 5) communicate learning expectations, 6) motivate and focus learner attention and effort, 7) provide a basis for learner evaluation, 8) gauge programme effectiveness.

(p. 5)

Assessments unavoidably involve judgements that have the potential to affect learners either positively and negatively (McMillan, 2000; McTighe & O’Connor, 2005). It is thus important to ensure that assessments are valid, fair and ethical. In the Namibian context assessments are either formative or summative in nature, as inferred from the way assessments are used (Mansell, et al., 2009).

Formative assessment is “assessment for the purpose of instruction” (Heritage, cited in Ginsburg, 2009, p. 110). In this type of assessment feedback or evidence is used to modify or improve teaching
and learning (Good, 2011). In Namibia, formative assessment is also known as continuous assessment (CA). The two words are used synonymously because the two procedures consist of regular, informal and formal assessments aimed at improving learning and directing teaching (Marongwe, 2012; Namibia. MBESC, 1999).

Continuous assessment (CA) in Namibia was introduced to complement the adoption of learner-centred education (LCE). CA represents an underlying principle of LCE (Kruger, 2004). The link between LCE and formative assessment lies in the contemporary learning theories of cognitive constructivism and social constructivism (Cohen, et al., 2004; Shepard, 2005). Formative assessment (CA) is an important element from a constructivist perspective because it can play a valuable role in scaffolding the learning process. Shepard (2005) reiterates that formative assessment and scaffolding in many senses play a similar role.

Summative assessment differs from the formative assessment mainly with respect to purpose and timing. Mansell, et al. (2009) summarise some of the characteristic differences between the two types of assessment as follows:

- Summative comes at the end of episodes, whereas formative is built on the learning process;
- Summative aims to assess knowledge and understanding at a given point in time, whereas formative aims to develop it;
- Summative is static and one way (usually the teacher or examiner judges the pupil) whereas formative is on-going and dynamic (feedback can be given both to the pupil and the teacher);
- Summative follows a set of pre-defined questions, whereas the formative follows the flow of spontaneous dialogue and interaction, where one action builds on (is contingent upon) an earlier one.

(p. 9)

The purpose of summative assessment is to review, to make an overall judgment in order to give strategic advice about the next stage of learning (Black, 2008). The score used to determine whether a learner can proceed to the next stage is called a promotional mark. Depending on the assessment policy of the country or examination board, a promotional mark sometimes comes from the final examinations only (summative score) or it can be a combination of formative marks (CA) and summative marks in a given ratio.
Mathematics assessment in Namibia at JSC level is controlled and regulated by the DNEA which is a Quality Assurance Department in the Ministry of Education. Formative assessment is carried out in both formal and informal ways. Marks are raised from the formal assessment that consists of 15 structured assessments. Summative assessment at JSC level consists of an examination with two components, Paper 1 and Paper 2. The results of CA and the examination results are combined in the ratio 7:13 to give the final promotional mark.

Arguing from a Namibian context, Alausa (1999, p. 7) believes that continuous assessment results, gathered over a long period, are more accurate when compared to a final examination because they reach the teacher early enough to enable the modification of instruction. This implies that unlike the end-of-year examinations, which are written in a short space of time, the use of continuous assessment gives a more accurate judgment of the learner’s performance over a longer period of observation. Furthermore, it helps to modify the teaching and learning process, thereby encouraging more teacher participation. McTighe and O’Connor (2005) reiterate that the continuous feedback from formative assessment improves teaching and learning. Kilpatrick, et al., (2001) believe that assessment enhances Mathematics proficiency by helping teachers “to adjust their teaching and identify students who need additional help” (p. 44). Assessment from this point of view creates opportunities for students to learn because improved assessment can lead to improved instruction (NAS, 2011).

Assessment practices that are compliant with the objectives of learner-centred education also create a platform of achieving the Namibian national goals of providing education for all. As an example, continuous assessment improves fairness of assessments. In addition, more assessment opportunities and methods are used which creates a variety of chances for learners to demonstrate their mastery of the learning objectives (Namibia. MBESC, 1999, p. 10).

In the school, assessment involves judgments and decision-making processes that go beyond the re-orientation of the teaching and learning process. Decisions that enable one to proceed to the next grade, and the consequences of placing learners in the wrong grade, cannot be underestimated. The process of assessing learners needs to be conducted with caution in order to avoid hurting the learners or the parents. The ability to make valid, reliable, free and fair judgment of learner performance is one of the challenges in Namibian schools.
Lack of assessment literacy among teachers is another challenge, and the development of assessment literacy amongst teachers is an important consideration in terms of reducing their dependency on formal testing and examinations. Reinforcing the importance of assessment literacy, Alausa (1999) acknowledges that Namibian teachers lack skills to set and administer tests that are reliable and valid. Literature reveals that the new assessment practices pose a challenge to the majority of Namibian teachers when it comes to implementation. The setting and keeping of records on the continuous assessment forms provided by the Ministry of Education remains a challenge even though a number of workshops have been conducted since the inception of the process. Over the years the DNEA has monitored continuous assessment marks handed in from schools and acknowledges that CA is “understood and well administered in some schools but not understood and poorly administered in others” (Mutuku, 2009, p. 1).

A close analysis of policy documents that have been published so far shows that lack of consistency in the use of terms like formative assessment, summative assessment and continuous assessment creates confusion. It is not clear in the Namibian context whether ‘formative assessment’, ‘continuous assessment’ and ‘summative assessment’ represent three different types of assessment (Namibia. MoE, 2006, p. 23) or whether there are only two modes of assessment in the country, ‘formative continuous assessment’ and ‘summative assessment’ (Namibia. MoE, 2010, p. 31). From this background it is not clear whether formative assessment and CA are synonymous. The unanswered question is whether CA is seen as a formal part of formative assessment or not. Pondering the confusion, Hamukonda (2007, p. 16) says that “continuous assessment can be either formative or summative or both”. Furthermore, there are inconsistencies in the use of the terms ‘promotional mark’, ‘final mark’ and ‘summative mark’ in terms of which one to use on the certificate of the learner at the end of Grade 10. It is likely that the irregular use of terminology may affect the implementation of the assessment process.

It is clear that assessment practices are not neutral spaces and that the implementation of assessment involves many stakeholders. Very little literature about research in assessment practices, implementation and administration has been published in Namibia. This study therefore attempts to fill the gap in the literature as well as provide evidence-based insight by evaluating Grade 10 Mathematics assessment (formative and
summative) procedures by investigating the perceptions of teachers and principals in the Oshikoto Region.

**Methodology**

This case study was grounded in the interpretive paradigm and followed a mixed methods approach. Quantitative and qualitative data were gathered in two sequential phases. Phase 1 involved the collection and analysis of official documents obtained from the DNEA. The raw data consisted of average CA and examination average marks for the period 2008, 2009 and 2010 for 62 JSC schools in the Oshikoto Region. The purpose of Phase 1 was to characterise the relationship between CA and average examination marks for the period 2008-2010. This data then formed an important backdrop to the second phase. Phase 2 involved the collection and analysis of qualitative data gathered from semi-structured interviews and a focus group discussion. Three Grade 10 Mathematics teachers together with their respective principals were drawn from the 62 JSC schools in the Oshikoto Region. These participants were purposively selected from each of the distinctive categories of schools identified in Phase 1. Schools fell into one of three groups: (A) those schools whose average CA mark was higher than their average examination mark, (B) those schools with comparable average CA and examination marks, and (C) those schools whose average examination mark was higher than their average CA mark. The purpose of the semi-structured interviews was to gain insight into teachers’ and principals’ perceptions of CA and end-of-year examinations as components of summative assessment. To corroborate and augment the evidence gathered from the structured interviews a focus group discussion consisting of twelve Grade 10 Mathematics teachers purposively sampled from the Oshigambo circuit in the Oshikoto region was conducted. The interviews and focus group discussion were recorded, transcribed, and analysed in terms of emerging themes that were refined over time.

**Findings and discussion**

The findings of the study are presented in such a way that they respond to the three research questions. Quantitative data responded to the first question, qualitative data responded to the second question, while a combination of qualitative and quantitative findings were used to respond to the third research question.
Research Question 1: What are the characteristics of the analyzed Grade 10 CA and end-of-year examination average marks for the period 2008-2010?

Analysis of average CA and examination marks for 2008 to 2010 revealed that schools could be classified into three categories based on the relationship between CA and examination marks (Table 1).

Table 1: Summary of 2008-2010 comparison of CA and examination marks

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<th>CA &gt; examination</th>
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<td>17</td>
<td>41</td>
</tr>
<tr>
<td>2009</td>
<td>4</td>
<td>24</td>
<td>34</td>
</tr>
<tr>
<td>2010</td>
<td>15</td>
<td>20</td>
<td>27</td>
</tr>
</tbody>
</table>

A general overview of Table 1 shows that the number of schools with CA marks greater than examination average marks remained the same for the period 2008-2009, while a sharp increase was noted in 2010. The number of schools where the CA marks were similar to examination average marks remained reasonably consistent for the three years. The number of schools where CA marks were lower than examination average marks declined from 2008 to 2010.

Scatter plots of CA marks versus the end-of-year examination marks for the 62 schools provide a deeper exploration of the relationship. Correlation coefficients were calculated based on a linear regression model.

Figure 1: Scatter plot for 2008 CA and examination average marks
Figure 2: Scatter plot for 2009 CA and examination average marks

![Scatter plot for 2009 CA and examination average marks]

Figure 3: Scatter plot for 2010 CA and examination average marks

![Scatter plot for 2010 CA and examination average marks]

The data from 2008 (Figure 1) reveals a weak correlation between CA and examination average marks \((r = 0.31)\). For a given CA mark, Figure 1 shows a range of corresponding examination marks. By way of example, while five schools scored an average CA mark of 35%, their corresponding average examination marks ranged from 41% to 79% (specifically, 41%, 52%, 56%, 66% and 79% respectively). As with 2008, the graphs for 2009 and 2010 also show only a weak correlation between CA and examination average marks, although this correlation gradually strengthened from \(r = 0.31\) in 2008 to \(r = 0.42\) in 2010.
What are the teachers’ and principals’ perceptions of CA and end-of-year examinations as components of summative assessment in Grade 10 Mathematics?

Although CA has potential benefits for both the teacher and the learner, 30% of the participants perceived CA as a means of assessing the understanding of learners without necessarily using the results to alter instructional methods. There is thus evidence to suggest that some teachers don’t fully appreciate the purpose or potential value of CA in spite of the fact that all respondents agreed that they cannot teach effectively without the use of CA.

The JSC syllabus used in Grade 10 clearly states that as part of formal continuous assessment the following should be included in the 15 structured assessments: 5 written tests, 4 practical investigations, 1 project and 5 topic tasks. The results of this study highlight the fact that many teachers are not sufficiently familiar with the CA components as required by the assessment policy and are thus not fully aware of the formal tasks that they are supposed to prepare and provide to learners in order to generate CA marks. There is also evidence to suggest that some teachers lack confidence in setting certain types of CA activities.

In general, most participants seemed to be reasonably aware of the similarities and differences that exist between CA and the final examinations. However, there was a strong perception amongst both teachers and principals that CA marks can easily be inflated through the setting of easy or substandard tasks, cheating on the part of the learners, and manipulation of marks on the part of teachers or principals. Interestingly, there was a general perception that those teachers who gave their learners high CA marks in comparison to the examination marks were either incompetent or dishonest. By contrast, teachers who achieve a balance between CA and examination marks are believed to know their learners very well and are seen as being fair, transparent and honest. Those teachers who produce CA marks that are significantly lower than the examination marks were generally perceived to be strict and who provided good quality but challenging CA tasks, although some respondents felt that such a scenario was unfair on the learners. On choosing the most ideal scenario, 83% of the respondents believed it was better for schools to obtain lower CA marks when compared to examination average marks since learners need to be challenged. Furthermore, there was a general perception that examination marks are more reliable than CA marks since, unlike CA, examinations are standardised and well regulated.
In general, most participants regarded CA as an important component of teaching and learning, with all respondents agreeing that they cannot teach effectively without the use of CA. However, differences emerged with regard to opinions in the way CA marks should be used as components of promotional marks. 10% of the respondents suggested that the two components (CA mark and examination mark) should be combined in the ratio 50:50 as opposed to the current ratio of 35:65. Two fifths of the respondents suggested that CA should not form part of the promotional mark in Grade 10. A further two fifths of the respondents were of the opinion that if CA is to be used as part of the promotional mark then CA activities need to be moderated and standardised by the DNEA.

What is the relationship between the teachers’ perceptions and the observed discrepancies between CA and examination average marks?

The results of this study suggest that teachers and principals have strong perceptions that CA marks can influence the final promotional mark in a number of ways. CA marks represent 35% of the promotional mark, and high CA marks can thus positively influence overall pass rates. The process of CA was also seen as important in terms of the final promotional mark since CA activities have the potential to prepare learners for the final examinations which form 65% of the promotional mark. However, a comparison of CA and examination marks over the years 2008, 2009 and 2010 shows a weak correlation between these two components of the promotional mark. As such, average CA marks are a poor indicator of average examination marks in Grade 10.

There is a general perception that teachers who are competent in continuous assessment produce CA average marks that are similar to the examination average. These teachers were described as mentors who can set CA content that is similar in standard to the examination. DNEA officials in their workshops have also advocated for teachers to strive for CA marks that are in line with examination marks. However, the document analysis for the years 2008, 2009 and 2010 shows that only a quarter of the schools managed to achieve this balance. This raises two interesting questions. What processes need to be put in place to ensure that schools are able to achieve this balance between CA and examination marks? More fundamentally, is this balance between CA and examination marks necessarily the best relationship to strive for?
Conclusion

Within a school context, issues of assessment inescapably involve the judgment of learners. When poor or inappropriate assessments lead to poor judgments being made, it is ultimately the learners who suffer. Assessment thus bears with it an important and unavoidable moral or ethical dimension. This study has shown that Grade 10 assessment practice in Namibian schools is far from ideal. Ministerial assessment policy needs to be supported to ensure appropriate implementation. In the words of Kilpatrick, et al. (2001, p. 13), “Mathematics assessments need to enable and not just gauge the development of proficiency”. The study suggests the following recommendations: (i) Grade 10 Mathematics assessment practice should be supported by assessment literacy programmes (e.g. training workshops) across the country, (ii) the CA process should have some level of standardisation as well as administrative support in schools, (iii) the quality and uniformity of CA activities could be improved through a process of moderation, (iv) the clarity and transparency of CA adjustments needs to be improved, particularly when it comes to the combining of CA and examination marks to produce the promotional mark, and (v) the summative role of CA in Grade 10 should be regulated in order to avoid undermining the formative role of CA. In the final analysis, assessment should be embraced as an integral part of mathematical proficiency.

REFERENCES


UNDERSTANDING THE DIFFERENCES IN MARKING PERFORMANCE OF JSC MATHEMATICS MARKERS IN NAMIBIA: A CASE STUDY

ELIZABETH MUTUKU

This case study investigated the marking performance of markers of the National JSC examinations. In particular, the study investigated possible relationships between marking performance and markers’ mathematical proficiency, and possible effects of moderator comments on marked performance. Data was collected through benchmark tests, markers’ moderation records, and a periodic markers’ marking error score. A comprehensive qualitative investigation of the marking of a purposively selected sample of four markers was carried out, followed by in-depth interviews of these markers. A weak positive correlation was found between marking performance and the results of the benchmark test. Factors identified in the interviews as possibly influencing marking performance were gaps in knowledge of the JSC curriculum and difficulties in interpreting and using the marking scheme. Average markers demonstrated marking errors mainly in topics in which they had performed poorly in the test, while poor markers showed a high variability in their marking performance, making errors even in topics for which they had scored well in the test.

Introduction

The education reform process has put pressure on many countries around the world to overhaul their education systems. In Namibia, the reform process started after independence in 1990. Changing the Namibian system of mathematics education was one component of this reform. This change included ensuring the reliability and validity of national
examination results, which provide a measure of whether the newly introduced programmes are working or not. For the Ministry of Education this meant training more mathematics teachers and ensuring that competent and reliable teachers were appointed for marking the national examinations every year. The teacher training process however has not been going as successfully as envisaged, and year after year the Directorate of National Examinations and Assessment has experienced problems in obtaining competent markers for the national Mathematics examinations.

**Aim of the research and research questions**

The purpose of the study was to understand the differences in marking performances of the JSC Mathematics national examination markers. The specific aims of the study were to:

- Explore the possible effect of markers’ mathematical content knowledge on their marking performance.
- Investigate the possible influence of moderators’ comments on the performance of the markers.

**Context and literature review**

**Assessment: National Examinations**

Assessment is carried out for various reasons, including informing teachers in the classroom about the abilities of their learners, providing feedback to learners on what concepts they understand better and providing them encouragement and motivation for further studies. Assessment is also used for diagnostic and selection purposes (Wragg, 2001; Webb, 1992; Shepard, 2001; Namibia. Ministry of Education and Culture [MEC], 1993). Accurate assessment of students’ academic abilities has been identified as one of the most crucial variables related to effective instructional planning and positive student outcomes (Fuchs & Fuchs, 1986; Shinn & Bamonto, 1998).

National examination results in Namibia are used for certification and selection purposes (Namibia. MEC, 1993; Wragg, 2001; Namibia. Ministry of Education [MoE], 2006). For example, learners can only proceed from Grade 10 to Grade 11 in Namibia if they performed sufficiently well in their Grade 10 national examinations. Learners who do not qualify for selection to Grade 11 are certified to give them a chance to compete in the job market. Consequently, national
examinations create pressure on both learners and teachers to better their performance - now more than ever before (Webb, 1992).

Even though national examinations take up a small percentage of the time used for assessment in school, the information obtained from them can be used for a wide range of purposes. In particular, national examination results can be used to provide information on which a learner, a school or even the whole country can be judged (Wragg, 2001). Additionally, national examination results inform policy makers in government and other stakeholders in education systems around the world whether or not education programmes are effective (Webb, 1992). National examination results should therefore be accurate, valid, reliable and of high quality (Wragg, 2001).

Validity and reliability of examinations
The purposes of national assessment will not be fulfilled if strong emphasis is not placed on its validity and reliability. Validity refers to whether the examination measures what it is supposed to measure, while reliability refers to the consistency of the examination and all its activities (Crisp, 2008).

Various countries including Namibia ensure consistency and fairness in examinations that are used for selection and monitoring purposes by conducting national examinations. National examinations should be uniformly administered, targeting common specific instructional goals (Shepard, 2001). According to Wragg (2001) the most important factors that should be uniformly controlled in national examinations are: the content tested, controlled by using a common curriculum, the setting of test items, the marking of learners’ responses to the examination questions and the awarding of grades.

Correct assessment of students’ academic abilities has been acknowledged as one of the most crucial variables related to successful instructional development and positive student outcomes (Fuchs & Fuchs, 1986; Shinn & Bamonto, 1998). Without a valid and reliable assessment of students’ academic skills, instructional decision-making is unlikely to encourage academic competence (Martens & Witt, 2004). The issues of validity and more especially reliability are greatly affected by markers’ judgment (Wragg, 2001; Crisp, 2008). This research therefore looks at understanding possible influences on the judgment making of markers and thus possibly on the reliability of the examination results. One particular influence is the content knowledge of the markers.
Examination setting and marking

Examination setting
Examination is an integral part of teaching and learning; therefore, it is imperative for every teacher to have a clear understanding of the purpose of examination (Wragg, 2001; Webb 1992). Every teacher should be able to clearly set examination items that are valid and reliable and should also be able to understand what the examination is expected to achieve (Namibia. Ministry of Basic Education, Sport and Culture [MBESC], 2001).

To ensure consistent assessment, the examination items must be constructed in order to achieve the appropriate quality (MBESC, 2001; Wragg, 2001). Experience shows that judging the quality of items can be complicated but, as a starting point, teachers should consider the difficulty level of the items. In general, a good assessment ought to be at about the difficulty level of the average learner (MBESC, 2001). Likewise, consideration should be given to how well the test differentiates between learners’ abilities (MBESC, 2001).

Examination marking
Marking of examinations in Namibia is carried out through the assigning of scores (marks) to the learners’ responses using a standardized marking scheme. Teachers perform the marking of tests and therefore marking is part of the teacher’s practice (Kilpatrick, Swafford & Findell, 2001).

In a review of the literature, Hoge and Coladarci (1989) combined the results of empirical studies conducted over a number of years. Their findings suggested a strong connection between teacher judgments and student achievement. Given the significant role of teacher judgment in assessing learners’ academic achievement, a number of studies have examined the accuracy of these perceptions (Hoge & Coladarci, 1989). In their study, Suto, Crisp and Greatorex (2008) indicated that the core process of marking requires a marker to read the learners’ responses and utilise five cognitive strategies in order to assign a mark. The five cognitive strategies highlighted by Suto, et al. (2008) are matching, no response, scrutinising, evaluating and scanning. They also added that the marking process is influenced by a number of factors, namely: markers’ subject knowledge, markers’ teaching and marking experience, the examining and the teaching community, marking task demands, specific question and mark scheme features and candidate response features.
Experience shows that when a candidate’s response includes features that are different from the mark scheme for a specific question, although giving the same interpretation, some markers may not make the correct judgment. In their study, Nadas and Suto (2008) found that a marker’s subject knowledge and teaching and marking experience has a great influence on a marker’s self-confidence during the marking process. In another study Suto, et al. (2008) concluded that the learners’ response features and mark scheme features have a great influence on the affective reaction of a marker. Marking assessment requires a very high level of reflection on the learners’ response and the teachers’ actions towards those responses is vital.

In some instances the marking of simple calculations in mathematics tests is straightforward (Wragg, 2001). When more complicated questions are involved, these might result in different features in learners’ responses than the features reflected by the mark scheme. The marking of such questions can no longer be regarded as straightforward since, according to Suto, et al. (2008), the difference in features between the mark scheme and the learners’ response may influence the markers’ judgement.

From experience I have found that good mathematics markers appear to be teachers who appear to be proficient in Mathematics. A teacher who is proficient in Mathematics should be able to think critically and engage in multiple ways of solving problems. Ball (2003) stated that Mathematics teachers should master their content knowledge for the work they have to do. This includes accurately evaluating learners’ examination responses and giving appropriate judgment to answers given by learners.

**National Examination marking in Namibia**
The Directorate of National Examination and Assessments (DNEA) supervise the marking of national examinations in Namibia. Teachers from different parts of the country are selected as markers. These selections are carried out according to a set of rules. These rules include that the teacher should have been teaching the subject at the relevant grade for at least three years, that he or she should have a three year teachers’ qualification, and that their appointment should be approved by their school principal.

During the marking exercise, markers are separated into teams, each team with its team leader. The whole group is again controlled by the overall group leader called a chief marker. Team leaders are selected based on their continuously good performance in marking over a number
of years and the chief markers are the examiners (setters) for the examination paper being marked. Chief markers are responsible for monitoring the whole marking process. Apart from making sure that a clear marking scheme is available, chief markers together with the team leader markers have to make sure that markers are properly trained in how to apply the mark scheme. They also continuously monitor the marking process by moderating random samples of the scripts marked by the other markers. Having a clear mark scheme and a proper monitoring system enhances reliability and fairness. Teachers’ reflection on the different solutions to problems further enhances the validity and reliability of examination.

The selection process for markers employed by the DNEA is careful and strict. Yet there are teachers who find it difficult to mark according to the prescribed mark scheme. Many of these teachers fail to make the correct and appropriate judgment of the learners’ responses in the national examinations. They seem not to understand instructions given by their chief examiners or team leader markers. In order not to jeopardise the quality of the marking, such teachers are not allowed to continue marking.

Common errors and issues in marking performance
Errors in marking examinations commonly occur because of misinterpretation of how to apply the mark scheme. Lack of concentration has also been known to cause several errors in marking. Njabili (1993) stated that markers may lack concentration because of stress, exhaustion and be sidetracked by anything else during marking. She recommended that marking should not be done under mental stress.

Consistency in the application of the mark scheme is one of the biggest issues that may lead to errors in the marking process. Some errors could however happen in mechanical procedures such as adding marks within a question and/or the total of a learner’s answer sheet. To minimise or eliminate such errors, every marker’s work is checked for addition by a partner marker.

Difficult questions for marking
The most difficult questions to mark in Mathematics are questions that are classified as ‘follow through’ questions. These are questions with many dependent subsections, for example (a), (b) and (c). If an error in a learners’ response occurs in the first section of the question and this incorrect answer was used correctly in the next section, such answers
must be marked as being correct. For example, assume that the question has two sections (a) and (b), where the answer to section (a) should be used in the calculations in section (b) but unfortunately the learner’s answer to section (a) is wrong. If the learner uses (a)’s wrong answer to do the calculation in (b) correctly, this answer should be marked as a correct answer.

**Monitoring markers**
Markers in their teams are monitored by their team leader. Team leaders have the responsibility to ensure that each marker in their team applies the agreed mark scheme accurately. Furthermore, the team leader has to ensure that “the markers have a well-founded and a common understanding of the requirements of the mark scheme and can apply it reliably and consistently” (Namibia. MoE, 2007). This is done during the standardisation meeting.

It is important that on each occasion where moderating occurs, the marker is informed of any deviation from the accepted marking criterion and in some cases markers are instructed to re-mark the scripts that were marked together with the moderated scripts. They are also informed of the errors they made in order not to repeat the same errors.

**Teachers’ mathematical proficiency**
Mathematical proficiency as described by Kilpatrick, et al. (2001) is represented by five inter-dependent strands. These are: *conceptual understanding*; *procedural fluency*; *strategic competence*; *adaptive reasoning* and *productive disposition*. The teaching and learning of Mathematics is viewed as a product of interrelation between teachers, students and Mathematics in an appropriate context (Kilpatrick, et al., 2001). A marker is expected to understand this interaction to help them make accurate judgments. As indicated by Webb (1992), assessment with all its activities incorporates a number of features. These features include:

- teachers’ knowledge of subject content
- teachers’ knowledge of learners and how learners learn
- teachers’ knowledge about assessment activities themselves

To be able to teach effectively, a teacher has to master the subject content knowledge and at the same time acquire sufficient pedagogical content knowledge to help all students to develop proficiency (Kilpatrick, et al.,
Furthermore, teachers’ interpretation of their students’ work is guided by their own understanding of the mathematical content knowledge. A teacher will also do more effective teaching if they pay more attention to students’ work because students’ work can reveal what students can and cannot do (Fennema & Franke, 1992). Paying attention to students’ work also helps the teacher as a marker to make accurate judgments of student responses in the examination. Therefore, assessment activities in mathematics, which include the marking of national examinations, demand that teachers be proficient in Mathematics. However, the relationship between different levels of proficiency for different strands of proficiency and the effective marking of different types of questions is not immediately apparent.

**Methodology**

The research was a case study that explored a single observable fact or entity bounded by time and activity and detailed information through a variety of data collected (Cohen, Manion & Morison, 2000; Patton, 1990; Creswell, 1998). The bounded system in this research was the group of Mathematics markers for the JSC national examination for one particular year. The marking performance of JSC Mathematics national examination markers on Paper 2 was the observable fact studied. In particular, the research investigated the possible effects of marker content knowledge and of moderators’ comments on marking performance.

According to Galliers (1991) a case study method allows a researcher to ask ‘how’ and ‘why’ questions. The research focussed on asking ‘why’ there were differences in markers’ marking performance of JSC Mathematics national examinations and also ‘how’ the markers’ Mathematics content knowledge may have influenced their marking performance.

All 86 JSC Mathematics markers were given a diagnostic test. However, the analysis concentrated on the markers who marked Paper 2. The markers’ moderation records were used to generate a marking error score for every marker. The marking error scores were used to categorise markers in three categories; **good**, **average** and **poor** markers. A sample of 13 markers was selected for a question-by-question analysis. This analysis compared the markers’ performance in the test and in the marking as reflected by the moderation record form. Of the 13 markers, 3 had been categorized as **good** markers, 5 had been categorized as **average** markers and the remaining 5 had been categorized as **poor** markers.
A comprehensive qualitative investigation of the markers’ differences in marking was carried out on a smaller sample of four of the 13 markers. The sample was made up of three females and one male. Their names were Thomas, Selma, Johanna and Sara (all fictitious names). The participating teachers had varying teaching and national examination marking experience. The selection of the participants was such that one was a weak marker, one an average marker and two were good markers. The diversity in performance was chosen to ensure a spread of all levels of marking proficiency.

In order to investigate the impact of moderators’ input on the progressive performance of markers, a periodic markers’ marking error score was worked out regularly. It is expected that the periodic markers’ marking error score should decrease gradually as the marking process progresses. To be able to observe how the impact of the moderators’ input varies from team to team, four different teams (teams 2, 3, 6, and 7) were selected for further analysis.

Findings and discussion

The research provided sufficient data to show that there were differences in markers’ marking performance throughout the JSC Mathematics marking session for the 2007 national examination. This was evident from the marking error scores assigned which ranged from 21 to 144. The marker with the smallest marking error scores was the best marker. Some markers made more marking errors than the others and a number of them made marking errors that involved more marks than others.

It also emerged from the data that there were differences in the impact the team moderators’ input had on the markers’ marking performance. Therefore, further analysis of the moderation records was carried out to establish the trends in the periodic marking performance of teams.

There were differences in markers’ marking performance throughout the JSC Mathematics marking session. The marking error scores ranged from 21 to 144 (the smaller error scores indicating better marking). Relating this to markers’ mathematical subject knowledge, good and average markers generally had fewer incorrect questions in the test and poor markers had more. This was supported by the positive Pearson product moment correlation coefficient between the markers’ test error scores and their marking performance as indicated by their marking error scores.
Looking at errors in the different marking categories, the average markers generally made more marking errors in questions on the same topic as their incorrect test questions. This may be seen in the following table.

**Table 1: Summary for question-by-question comparison for the average markers**

<table>
<thead>
<tr>
<th>Marker</th>
<th>Topic</th>
<th>No of test Errors</th>
<th>No of marking Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M4(2:02)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numbers</td>
<td>0</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Money and finance</td>
<td>1</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Measures</td>
<td>0</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Mensuration</td>
<td>No question</td>
<td>No question</td>
<td></td>
</tr>
<tr>
<td>Geometry</td>
<td>0</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Algebra</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Graphs and functions</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Statistics and probability</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Trigonometry</td>
<td>0</td>
<td>No question</td>
<td></td>
</tr>
<tr>
<td><strong>M5 (3:04)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numbers</td>
<td>1</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Money and finance</td>
<td>0</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Measures</td>
<td>0</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Mensuration</td>
<td>No question</td>
<td>No question</td>
<td></td>
</tr>
<tr>
<td>Geometry</td>
<td>0</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Algebra</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Graphs and functions</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Statistics and probability</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Trigonometry</td>
<td>0</td>
<td>No question</td>
<td></td>
</tr>
<tr>
<td><strong>M6(4:02)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numbers</td>
<td>1</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Money and finance</td>
<td>3</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Measures</td>
<td>0</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Mensuration</td>
<td>No question</td>
<td>No question</td>
<td></td>
</tr>
<tr>
<td>Geometry</td>
<td>0</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Algebra</td>
<td>0</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Graphs and functions</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Statistics and probability</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Trigonometry</td>
<td>0</td>
<td>No question</td>
<td></td>
</tr>
</tbody>
</table>

In contrast to this, poor markers showed a considerable spread in marking errors, making errors in most topics, even those in which they had scored well in the test. This can be seen in the following table:
Table 2: Summary for question-by-question comparison for the poor markers

<table>
<thead>
<tr>
<th>Marker</th>
<th>Topic</th>
<th>No of test Errors</th>
<th>No of marking Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M9 (2:07)</strong></td>
<td>Numbers</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Money and finance</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Measures</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Mensuration</td>
<td>No question</td>
<td>No question</td>
</tr>
<tr>
<td></td>
<td>Geometry</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Algebra</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Graphs and functions</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Statistics and probability</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Trigonometry</td>
<td>0</td>
<td>No question</td>
</tr>
<tr>
<td><strong>M10 (3:02)</strong></td>
<td>Numbers</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Money and finance</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Measures</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Mensuration</td>
<td>No question</td>
<td>No question</td>
</tr>
<tr>
<td></td>
<td>Geometry</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Algebra</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Graphs and functions</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Statistics and probability</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Trigonometry</td>
<td>0</td>
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It was also evident from the findings that poor markers had in most cases a very high total number of errors in marking some if not all questions. The data suggests that both average and poor performing markers are not comfortable with their content knowledge.

The marking performance and the diagnostic test performance positively correlated with a Pearson product correlation coefficient of $r = 0.43127$. However, the correlation is fairly weak. This could imply that there are other very significant factors that are also influencing the markers’ marking performance. Factors identified in the interviews with markers included knowledge of the JSC curricula and interpretation and usage of the marking scheme.

Interpreting and using the marking scheme is about making sense of, and then marking with reference to, the mark scheme. This is related to teachers’ conceptual knowledge. Poor and average markers tended to struggle with interpreting and using the marking scheme. In interviews, some markers were not clear when describing how the mark scheme should be applied. Others appeared to explain the opposite of how the mark scheme was applied – indicating that they may have completely misunderstood how to apply the marking scheme.

Although knowledge of the curricula is not directly measured in this research, the results show that some of the poor performing markers had little knowledge of the JSC Mathematics curriculum. For example, this was evident in the interview with one teacher who seemed to think (incorrectly) that the topic of probability was no longer in the JSC syllabus.

Marking performance was influenced by markers’ mathematical content knowledge. However, results also show that markers’ mathematics content knowledge needed for the marking practice cannot be measured only by their formal mathematical qualification. One other influencing factor was that markers come from different socioeconomic backgrounds and these seemed to have affected the development and

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expansion of their mathematical content knowledge. On one hand markers from a poorer socioeconomic background tended to think that their background might have influenced the level of their content knowledge negatively, while some markers from richer socioeconomic backgrounds performed well in the test and the marking, despite not having formal training in Mathematics. One of these teachers claimed that her mathematical knowledge developed due to the assistance received from her school.

The research findings also revealed that the moderators’ standardisation meeting and their input when providing feedback on errors made by markers had contributed to the differences in marking performance of the JSC Mathematics national examination markers for 2007. It was disturbing to realise that some teams had all their markers categorised as either poor or average markers. Other teams had all their markers categorised as good markers. This highlighted the differences in the leaders’ performance and the effectiveness of their training and continuous feedback. The findings also suggest that the markers’ marking performance can be improved by extending the markers’ training session for markers identified as weak during the trial marking. Extending the marking period or reducing the number of scripts assigned to markers could also improve marking performance.

**Conclusion**

This study supports the need to improve teachers’ mathematical content knowledge in order to improve the marking of National Mathematics examinations. Nonetheless, marking performance was only weakly correlated with content knowledge – a number of other factors contributing to marking performance were identified, including curriculum knowledge and the capacity to effectively interpret marking schemes. This suggests that teacher training in these areas may also be important. It was also found that teachers’ formal qualifications in Mathematics did not necessarily relate directly to their mathematical content knowledge, or their marking performance – pointing to the difficulties inherent in selecting markers based on mathematical qualifications alone. Finally, it was evident that team moderators could have a strong influence on the marking of the teachers in their teams (both for good and for bad). The selection and training of team moderators is thus an additional aspect to which great care needs to be given.
REFERENCES


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AN ANALYSIS OF THE DISTRIBUTION AND USE OF TEACHING AIDS IN MATHEMATICS IN SELECTED WINDHOEK SECONDARY SCHOOLS

TOBIAS DZAMBARA

This study investigated the types of mathematics teaching aids available at both public and private secondary schools in Windhoek. The study characterises their usage and source as well as teachers’ perceptions towards the use of such teaching resources in the Mathematics classroom. The study involved 75 Mathematics teachers from 25 secondary schools in Windhoek. The results of the study showed that the majority of teachers at secondary schools in Windhoek have a positive attitude towards the importance and role of teaching aids in Mathematics, seeing them as promoters of hands-on engagement, visual reasoning, active participation and motivation amongst learners. However, in some instances schools are under-resourced with respect to certain types of teaching aids, specifically graph boards, geoboards, geometric models and computers. A need for appropriate in-school support on the use of teaching aids was also identified.

Introduction and background context

The educational system in Namibia went through a process of transformation after the country obtained political independence in 1990. Bearing in mind that learner-centred education (LCE) was at the heart of the new educational system, the policy on quality education recognized that the challenge was “to develop instructional strategies that make it possible for learners from varying backgrounds and with differing abilities to all progress” (Namibia. Ministry of Education and Culture [MEC], 1993, p. 39). It further stipulated that the basic education system saw Mathematics as a subject designed to promote functional numeracy
and mathematical thinking by helping learners to develop a positive attitude towards the subject, acquire basic mathematical concepts as well as to develop a “lively, questioning, appreciative and creative intellect” (p. 56). The use of appropriate teaching aids and resources was encouraged as a means to achieve this vision. The Broad Curriculum document of the Basic Education Teacher Diploma (BETD) in Namibia clearly outlines the Ministry of Education’s expectations from teachers with regard to LCE and the usage of teaching aids in schools:

Teachers should be able to select content and methods on the basis of the learners’ needs, use local and natural resources as an alternative or supplement to readymade study materials and thus develop their own and the learners’ creativity. A learner-centred approach demands a high degree of learner participation, contribution and production.

(Namibia. Ministry of Education [MoE], 2009, p. 2)

Teachers not only play a pivotal role in the teaching of Mathematics in a learner-centred environment but facilitate the participation of all learners through the use of teaching resources. The Namibian teacher is therefore expected to spearhead the teaching and learning process by encouraging active involvement and participation of learners. It is almost two decades after the original policy document on education spelled out the roadmap to quality education in Namibia, so the question is: How successful has the laying down of teaching methods and teaching approaches been in creating an educational environment where quality, efficiency and effectiveness in learning and teaching prevail in schools?

Aims of the research

The purpose of this study was to audit the availability and use of Mathematics teaching aids found in secondary schools situated in Windhoek, as well as to ascertain the perceptions of teachers towards the use of such tools in their everyday lessons. Three important research questions framed the study:

- What type of teaching and learning aids are available for Mathematics teachers in the private and public secondary schools in Windhoek?
- What is the nature or character of the use of the available teaching aids?
• What are the teachers’ general perceptions on the availability and use of teaching aids in Mathematics at secondary school level?

**Literature review**

Evidence from comprehensive studies carried out in the USA by Suydam and Higgins (1977) on the use of manipulatives concluded that “lessons using manipulative materials have a higher probability of producing greater mathematical achievement than do non-manipulative lessons” (p. 83). In a study on the influence of teaching aids in Mathematics (Raphael & Wahlstrom, 1989) an examination of the interrelationships between the use of teaching aids, content coverage and student achievement revealed that greater use of teaching aids in Mathematics at secondary school level allowed for greater coverage of topics.

A study in some of Nigeria’s districts revealed that learners “retain better what they have been taught” (Afolabi & Adeleke, 2010, p. 407) and their interest in learning Mathematics is greatly sustained through the use of teaching aids. The use of teaching aids does not only improve learners’ perception of the learning experience itself but also provides an opportunity for learners to become actively involved in lessons (Van der Merwe & Van Rooyen, 2004, p. 229).

Weiss (2006, p. 239) points out that in the USA, the National Council of Teachers of Mathematics (NCTM) in 2000 developed principles and standards to address reform in the teaching of Mathematics by putting emphasis on a pedagogy that embraced students’ experiencing hands-on activities, encouraging conceptual understanding as well as strategic thinking – experiences that could readily be achieved through the use of teaching aids. This resonates with the Namibian focus on learner-centred education which foregrounds the importance of the learners’ active participation and meaningful contribution in a learner-centred approach (Namibia. MoE, 2003). The use of teaching aids at secondary school level should be encouraged because their use is likely to promote the process of learning Mathematics.

Teaching aids can provide valuable support for the learning process when teachers “interact over time with the students to help them build links between the object, the symbol and the mathematical idea both represent” (Kilpatrick, et al., 2001, p. 354). Teaching aids may serve as “tools for teachers to translate abstractions into a form that enables learners to relate new knowledge to existing knowledge” (Moyer, 2001, p.
and can play a critical role in learners’ “construction of meaningful ideas” (Clements, 1999, p. 56) when used in the “context of educational tasks to actively engage children’s thinking with teacher guidance” (p. 56). Mathematics manipulatives have “the potential to lead to an awareness and development of concepts” (Swan & Marshall, 2010, p. 14) because hands-on learning builds a better understanding.

The types of teaching aids focused on in this particular study include graph boards, interactive whiteboards, geoboards, mathematical instruments for the chalkboard, charts and posters, geometric models, mathematical sets, calculators, graph paper, overhead projectors, computers, improvised teaching aids made using available resources, as well as any other physical artefacts that facilitate teaching and learning. In the interests of clarity, within this study the term “teaching aid” is used as an all-encompassing umbrella term referring to all teaching resources found and used in the Mathematics classroom to enhance teaching and learning.

As a teacher educator of Mathematics working with trainee teachers, the importance of resources in the teaching of Mathematics at secondary school level is strongly emphasized. However, formative as well as summative reports that emanated from school visits during the teaching practice of student teachers indicated that qualified teachers are not implementing the use of teaching aids comprehensively in secondary school Mathematics lessons. This situation is by no means unique to Namibia. By way of example, in a survey of middle schools in Western Australia, Perry and Howard (cited in Swan & Marshall, 2010) found that while the use of manipulatives was widely supported by most primary teachers across all years and for all fields of Mathematics, there was little use of teaching aids in secondary school mathematics. Furthermore, a significant percentage of teachers pointed out that they needed professional training on the use of teaching aids in the subject.

Methodology

This case study is grounded in the interpretive paradigm and made use of a mixed methods approach wherein both quantitative and qualitative empirical data was collected in two sequential phases. In the first phase mostly quantitative data was collected by means of a standardized questionnaire instrument from all secondary schools in the Windhoek metropolitan area to provide information on the overall availability of teaching aids in Mathematics. The questionnaire also made use of a Likert scale rating system to measure and quantify participants’ attitude towards
the use of teaching aids. The statistical data from this audit was used to purposefully select five secondary schools from which qualitative data was collected by means of semi-structured interviews with teachers from the selected schools. The five schools were purposefully selected in order to characterize the use of mathematical teaching aids in schools with different contexts: (i) two schools that had adequate resources and showed good practice in the use of teaching aids, (ii) two schools where the availability of teaching aids was scarce, and (iii) one school with a moderate supply of teaching resources. Semi-structured interviews were conducted with the five targeted teachers to corroborate and expand on data that emerged from the first phase of the study.

The quantitative data collected from the questionnaires was analysed using spreadsheet software to identify any trends and patterns in the use and availability of teaching aids in schools. Qualitative data from the interviews was transcribed and coded. Themes that emerged from this process were gradually grouped to provide a rich and deep characterization of teachers’ experiences and perceptions of the use of teaching aids in the Namibian Mathematics classroom at secondary school level.

**Findings and discussion**

In Phase 1 of the research, questionnaires were delivered to 100 secondary school Mathematics teachers at 30 different secondary schools. 75 teachers at 25 of the schools completed the questionnaire.

**Figure 1: Frequency of use of teaching aids in all schools**

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<td>Never used</td>
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<tr>
<td>Used as frequently as possible</td>
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<tr>
<td>Used on a daily basis</td>
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Thirteen different types of teaching aid were audited giving a total of 975 potential responses. In terms of the availability of the teaching aids there were a total of 911 responses, 53% of which indicated that the particular teaching aid was available. This suggests that there is reasonable availability of the different types of teaching aids surveyed in the schools that were audited. With respect to the use of teaching aids, the survey shows that only a limited number of teaching aids are used on a daily basis (11%) while 40% are used as frequently as possible. 49% of the teaching aids were indicated as being never used (Figure 1).

With respect to the source of the teaching aids surveyed, the major source was school purchase (47%) followed by personal purchase (35%). This makes personal purchase the second-highest source of teaching aids in the schools surveyed, and highlights the readiness and willingness of some teachers to take responsibility for sourcing and financing personal teaching aids for their classroom teaching and learning.

![Source of all teaching aids](image)

The types of mathematical teaching aids most readily available include: charts and posters; chalkboard 30° & 60° set squares; chalkboard rulers, protractors and compasses; mathematical sets for learners; overhead projectors; and improvised teaching aids. For each of these teaching aid categories teachers indicated a greater than 60% availability. The availability of physical objects (other than geometric models), geometric models and computers/laptops was calculated as being in the 60% to 40% range, and such teaching aids can be classified as being moderately available. Graph boards, interactive whiteboards and geoboards were the least available items with availability scores of 21%, 12% and 3% respectively. Only two of the 75 teachers indicated that they had geoboards in their classrooms. This is surprising since this useful
instrument can easily be improvised and is a simple but effective means of engaging with topics in geometry (e.g. transformations).

The Likert scale was used to gather teachers’ opinions on broader issues related to the use of teaching aids in Mathematics lessons in their schools. Approximately 78% of the participants agreed (46% strongly so) that availability of relevant and adequate resources was necessary for effective delivery of Mathematics lessons at secondary school level. There was thus an implicit consensus among teachers that teaching aids not only promote active participation and interest among the learners but also promote teaching for mathematical proficiency.

In under-resourced schools there is a pressing need for teachers to be able to take the initiative and come up with simple but innovative ways of improvising appropriate teaching aids. Approximately 58% of the participants agreed (23% strongly so) that Mathematics teachers were in a position to easily improvise effective teaching aids from limited resources. Only 15% of the participants disagreed with this position. This correlates well with the availability of improvised teaching aids where 65% of the teachers indicated the availability of improvised teaching aids in their schools. Nonetheless, the availability of time to prepare teaching aids appears to be a problem for the teachers who participated in this study, with only 23% of the teachers indicating that they have time to make teaching aids. Interestingly, 74% of the participants felt that they needed in-service training on the use of teaching aids to supplement the skills acquired at training institutions.

During the analysis of the qualitative data, common themes gradually emerged through repeated engagement with the data. The themes that emerged related to: hands-on nature of concrete objects; reality and visualization; enhanced teaching of concepts; active participation and interest; inadequate resources and the need to improvise; motivation and learner performance; and time and support from the ministry. General perceptions of teachers towards the use of teaching aids in secondary schools are summarized here in relation to these themes.

**Hands-on nature of concrete objects**: Teachers were of the opinion that the use of teaching aids at secondary school should be encouraged because the use of tangible, hands-on objects in their Mathematics lessons helps them to explain abstract mathematical ideas more effectively. Some teachers felt that this hands-on physical contact with manipulatives was particularly beneficial for weaker learners.
Reality and visualization: Teachers believed that teaching aids provide learners with real-life experiences which support in the visualisation and conceptualization of mathematical ideas. Teaching aids were also believed to provide an invaluable link between the real world and the mathematics being taught.

Enhanced teaching of concepts: Teachers were generally of the opinion that the use of teaching aids at secondary school level enhances the learning and teaching of Mathematics by promoting long-term understanding of mathematical concepts.

Active participation and interest: Teachers were of the opinion that teaching aids promote learners’ active participation and interest in Mathematics, thereby promoting the notion of learner-centred education as advocated by the Ministry.

Inadequate resources and the need to improvise: Despite many schools being under-resourced, some teachers took the initiative of either borrowing resources from neighbouring schools or improvising with home-made teaching aids.

Motivation and learner performance: Teachers believed that teaching aids have the potential to encourage motivation as well as a positive attitude towards the teaching and learning of Mathematics. In addition, many teachers felt that the use of teaching aids contributed to good academic performance in examinations.

Time and support from the Ministry: While teachers value the importance of using appropriate resources and teaching aids in their lessons, it became evident that time constraints prevent the majority of teachers from preparing their own teaching aids. There was also a widespread expectation from teachers that the Ministry of Education should take responsibility for supplying schools with appropriate resources.

In addition to these themes it is worth highlighting that although 50% of the participants felt that graduate teachers leave training institutes with adequate knowledge on the use of teaching aids in Mathematics, almost three quarters of the participants felt that they required more in-service training on the use of teaching aids.
Conclusion

This study focused on assessing the availability and usage of teaching aids in Mathematics at secondary schools (both public and private) located in Windhoek. The study also aimed at developing a more nuanced and in-depth understanding of the use of teaching aids at purposefully selected schools, as well as teachers’ perceptions towards the use of these teaching resources in their Mathematics lessons. The effective use of teaching aids in a LCE environment in the Namibian educational context is intended to encourage active participation and to help learners discover and build co-operative skills and to promote problem solving skills and foster creative thinking.

Despite many schools being under-resourced in terms of teaching aids, this study revealed that some teachers were prepared to take ownership of this problem and either borrowed resources from neighbouring schools or improvised with home-made teaching aids. Such creativity and resourcefulness is both heartening and encouraging.

Based on the results of this study, the following recommendations are put forward:

- The Ministry of Education should be encouraged to strengthen the teaching and learning of Mathematics at secondary schools by providing adequate teaching resources in the form of teaching aids.
- The institutes of higher learning tasked with producing secondary school teachers should work in collaboration with the Ministry of Education to provide in-service support on the use of teaching aids to practicing teachers.
- Instances of teacher creativity and resourcefulness need to be shared more broadly within the Namibian educational landscape as examples of best practice and as examples of what is possible despite limited resources.

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CONTRIBUTORS
(in order of contributions)

EDITORS

Professor Marc Schäfer holds the FRF Mathematics Education Chair at Rhodes University in Grahamstown, South Africa. He coordinates a research and development programme in the Eastern Cape as well as a Mathematics Education Masters programme in Namibia. He is a past president of SAARMSTE and is passionate about research in Mathematics Education and its impact on transforming Mathematics Education in Southern Africa. He supervises Masters and Doctoral students in numerous contexts.

M.Schafer@ru.ac.za

Dr Duncan Samson is a researcher for the FRF Mathematics Education Chair at Rhodes University in Grahamstown, South Africa. He is passionately involved in the delivery of teacher development seminars and hands-on workshops, materials and resource development, and related research projects. In 2014 he was awarded the inaugural Emerging Researcher Award at the 22nd annual SAARMSTE conference in Port Elizabeth, South Africa.

D.Samson@ru.ac.za

Dr Bruce Brown is the HOD of the Education Department at Rhodes University. He has been involved in the professional education of teachers since 1997. Trained as a mathematician, his particular interest are the mental, interpersonal and instrumental systems of interaction in the process of learning mathematics at all levels (Grade R to University) and the manner in which these interactions influence individual understanding and practice of mathematics.

B.Brown@ru.ac.za
Mr Robert Kraft is manager of the Rhodes Namibian BEd Honours and MEd programs. His teaching includes assessment for learning, economics, research methods, English and story-telling. But his primary focus is academic literacy and supporting students in structuring and writing up their research. Prior to joining Rhodes he worked for a Canadian Bank, UNISA Business School and the Trade Union Council of South Africa.

R.Kraft@ru.ac.za

Professor Di Wilmot is the Dean of Education at Rhodes University. She was a founding member of the team from Rhodes University who taught on the Namibia BEd(Hons) programme in the 1990s. This was a response to the Namibian Ministry's call for post-graduate teacher professional development for the successful enactment of the learner-centred education as advocated by the Education for All policy. Professor Wilmot supervises Masters and Doctoral students, teaches and publishes in the field of Geography Education and Curriculum.

D.Wilmot@ru.ac.za

Dr John Nyambe is the founding Director of the Continuing Professional Development (CPD) Unit at the University of Namibia, a Unit which is responsible for coordinating and organizing opportunities for ongoing teacher learning beyond their initial university teacher education. He has held several positions in teacher education and has published widely on teacher education reform in Namibia.

jnyambe@unam.na
**Mr Muhongo Mateya** is a Senior Education officer for Mathematics at the Regional Office of Education in Kavango Region, Namibia. He advises and supports mathematics teachers by conducting workshops and in-service training sessions in the region. His emphasis is on effective implementation of the Mathematics Curriculum for Grades 5-12. He is currently reviewing literature to determine the relationship between geometric thinking and Algebra at Grades 10-12.

Mmateya67@yahoo.com

**Ms Maria Ngola-Kazumba** is a Junior Secondary Mathematics teacher. She holds a Master Degree in Mathematics Education from Rhodes University which she obtained in 2012. In 2005 she was appointed as a National Mathematic marker as well as one of the Mathematics Regional facilitators in Kavango Region. She would like to be a lecturer one day and pursue her Doctorate Degree in Mathematics Education.

Mkazumbangola@yahoo.com

**Ms Reginald lipinge** was a teacher and is now a Quality Assurance coordinator at the Polytechnic of Namibia (transforming into Namibia University of Science and Technology). She holds a Masters degree in Mathematics Education from Rhodes University obtained in 2013. She was a high school Mathematics and Biology teacher since 2005. She is passionate about quality research in teaching Mathematics and would like to pursue a Doctoral degree in that area.

riipinge@polytechnic.edu.na
Mr Danie Junius is a teacher in Mathematics, Physical Science and Computer Studies at a private school in Windhoek. Mathematics remains his first love and he is widely involved in assisting learners to improve their Mathematics marks so that they can get access to further studies in the Sciences. He spends a lot of time studying different approaches in teaching Mathematics to ensure that more learners are successful in their final Mathematics examinations.

djunius@windhoekgymnasium.com

Mr Bosman M. Simasiku is a Mathematics Education lecturer at the University of Namibia Katima Mulilo Campus. He served as a Mathematics teacher educator at the Caprivi College of Education in Namibia for a number of years. He was also a secondary school mathematics teacher in Namibia. He recently presented his research findings at the 2013 SACHES Conference, 2012 and 2013 UNAM research day.

bosmansimasiku@yahoo.com

Ms Beata Dongwi teaches Mathematics at Etosha Secondary School in Oshikoto Education Region, Namibia. She is passionately involved in shaping young mathematicians both at Junior and Senior Secondary levels via daily mathematical interactions. In 2013 she was awarded the best Additional Mathematics teacher as well as best teacher in the region at the Oshikoto Regional prize giving ceremony in Oshigambo High School.

bdongwi@yahoo.com

Mrs Ndamononghenda Vatilifa is a lecturer for Mathematics Education at the University of Namibia based at Hifikepunye Pohamba Campus, in Ongwediva, Namibia. She is passionate about exploring problems facing both teachers and learners in the teaching and learning of mathematics.

nvatilifa@unam.na or
ndamonavatilifa@yahoo.com
Mr Fillemon Ndinelago Vatilifa is a Senior Education Officer in the Mathematics and Science Department at the Rössing Foundation based in Ondangwa, Namibia. He is passionate about the enhancement of teaching methods for mathematical problem solving, through the use of appropriate experiential strategies.

firevatilifa@yahoo.com or Fillemon.Vatilifa@riotinto.com

Ms Charity M. Ausiku is a Mathematics Education lecturer at the University of Namibia, Rundu Campus. She holds a master’s degree in Mathematics Education. Her current research interests lie in Mathematics pedagogy at the primary phase. Her position as a Teaching Practice Coordinator at Rundu Campus has resulted in her keen interest in conducting research on student-teachers’ experiences during their Teaching Practice in schools.

causiku@unam.na

Mrs Luiya Luwango is a lecturer at the University of Namibia (UNAM) offering Child Development, Childhood Learning and Learning Support in the Mathematics classroom for early childhood education. She coordinates the department of Educational Psychology and Inclusive Education at Rundu UNAM Campus. She is passionate about research in childhood learning and Mathematics learning support.

lluwango@unam.na

Ms Julia Ndinoshisho Shilamba holds Masters Degree in Mathematics Education from Rhodes University. She is currently a Senior Education Officer (Mathematics grade 8-10) in the Omusati region Directorate of Education. In recent years she also taught Mathematics and Science Grades 5-12. She is passionate about mathematics exploration towards improving Mathematics education in Namibia.

juliashilamba87@gmail.com
Ms Loide Kapenda is a Chief Education Officer in the National Advisory Service in the Directorate: Programmes and Quality Assurance of the Ministry of Education, Namibia. Her interest lie in strengthening Mathematics and Science Education (SMASE) through her involvement in School Based Continuing Professional Development (SBCPD) for Mathematics and Science at Senior Primary level.
L.Kapenda@moe.gov.na

Mr Anesu Desmond Marongwe is a School Principal and an experienced secondary school Mathematics teacher. In 2014 he was awarded the best JSC and NSSC O’ level Mathematics teacher award in the Oshikoto Region of Namibia. For a record of six consecutive years he has obtained a 100% pass rate in JSC, Grade National Examinations. He believes that every student can do Mathematics successfully, given the appropriate opportunity.
anesumaron@yahoo.com

Ms Elizabeth Mutuku works for the Ministry of Education’s Directorate National Examinations and Assessment as a Chief Education Officer for the Science and Mathematics Subdivision.
emutuku@gmail.com

Mr Tobias Munyaradzi Dzambara is currently a lecturer for Basic Mathematics & Mathematics Education modules at the University of Namibia [Khomasdal Campus]. His interests do not only encompass the development of teaching resources in Mathematics at both primary and secondary school levels but he is also passionate about furthering his studies at doctoral level in the area of Mathematical knowledge for teaching.
tdzambara@unam.na or
tdzambara@yahoo.co.uk