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# South African School Geography: Underpinning the Foundation of Geospatial Competence

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## Abstract

*Within the broader South African curriculum, it is essentially in the geography classroom that geospatial competence is developed with the teaching of map reading, analysis and interpretation. After identifying reasons for the low levels of map literacy amongst the majority of school leavers in the past, the Geography curriculum reform policies introduced in 2000, 2005 and 2011 are reviewed. These reforms include an improved spatial skills development hierarchy and the introduction of Geographic Information Systems (GIS). The preparation and provisioning of teachers and how these factors impact on the geospatial competence of school-leavers is discussed. In conclusion, a case is made for enhancing the status of school Geography by making it a recommended subject for tertiary studies in university programs offering geospatial technologies.*

## 1. Introduction

The Geo-information industry in South Africa has grown rapidly, as it has in other countries. We are in the early phase of Geographic Information System (GIS) development in South Africa, where the majority of users are utilities such as municipalities and water and electricity suppliers, but Rossouw (2011) notes that it is location based services that are dominating the industry in the UK and elsewhere and the time is right to broaden the scope of GIS applications locally. Du Plessis and van Niekerk (2011) have outlined the pressing need for finding (or training) competent geospatial practitioners. When he presented his education report at the Annual General Meeting of the Geo-information Society of South Africa (GISSA), Roos (2011) outlined the route to professional qualifications in Geographic Information Science (GISc); the first step on that journey is acquiring map skills. It is in the geography classroom at school that these skills are usually acquired.

A brief history of geography teaching in South Africa is reviewed and how school Geography is now poised to prepare geospatially competent school leavers for a GIS-enabled future in South Africa is discussed. Geography is not currently a requirement for admission to university programmes offering geospatial technologies. It is suggested that Geography should be included in the list of recommended school subjects for geospatial qualifications because the map skills and other geographical competencies acquired when this subject is taught effectively at school would add significantly to the skill set of entry level tertiary candidates.

## 2. A Brief History of School Geography in South Africa

It is traditionally in the geography classroom that map skills are taught. Geography was introduced into the curricula of English schools in the Cape Colony in 1839 (Clark, 1989) but it was only in 1913 that a syllabus was proposed for the school leaving and university entrance examination or matriculation certificate (commonly known as matric). Acceptance as a university discipline came in 1916. The subject proved very popular throughout the Union of South Africa at secondary school level with pupil numbers initially growing faster than any other subject. By the time the Republic of South Africa was declared in 1960, the percentage of pupils selecting Geography as one of their matric subjects had dropped to about 25 % (Wesso and Parnell, 1992) of a much broader subject selection list.

Unfortunately any discourse on South African history necessitates a distinction between people designated by apartheid policies according to skin colour. An apology is offered for the unavoidable use of the terms White, Black, Coloured and Indian in the text that follows. During the apartheid years (1948 to 1994), Geography became well established in schools designated for those classified as White but the 'introduction of the subject to other groups was impeded by inadequate funding, a chronic shortage of specialist teachers, a short school life, problems related to the language of instruction, and a belief that a restricted curriculum, offering less range and depth, was more appropriate for the 'needs' of particular groups' (Clark, 1989: 48). It was often taught in a piecemeal fashion with mission schools for Black learners offering Geography at primary level only. Clark (1989) reports that in 1956 History, Geography and Nature Study were grouped as Environmental Studies in the first three years of primary school and that Geography was included with History, Citizenship, Safety Rules and Vocational Guidance in Social Studies for school years four to six. In 1967, Social Studies incorporating Geography, History and Civics became a compulsory subject for learners in years seven to nine at schools under the control of the Department of Education and Training (DET) which was responsible for Black learners. Mathematics instruction was badly neglected and very small numbers of pupils of colour completed the twelve years of schooling required for matriculation (Kallaway, 1984). The small proportion that selected Geography at senior secondary level followed a similar syllabus (with minor changes) as that prepared for White learners.

From the 1960s onwards there was an international move towards a more scientific approach to Geography which impacted on praxis in South African geography classrooms when a new syllabus was introduced in 1973. The Committee of Heads of Education (CHE) and the Joint Matriculation Board (JMB) selected the Cape Senior Syllabus for Geography, which had been revised and updated in 1964 and 1966 as the new, national core syllabus (van der Merwe, 1982). Implementation of the core curriculum remained the responsibility of a number of different examining bodies divided along both provincial and racial lines. These various examining bodies introduced a second geography examination paper for practical work during the latter half of the 1970s to assess map reading, analysis and interpretation (Clark, 1989). This was a significant step in fostering the teaching of geospatial skills in South Africa.

It was also during the 1970s that resentment towards segregated education for people of colour built up, leading to the Soweto Riots, school boycotts and the near collapse of Black education. In response to the education crisis of the 1970s and 1980s the Human Sciences Research Council (HSRC) appointed a Commission of Inquiry into Education with 'a brief to provide recommendations for an education system which would meet the manpower needs of South Africa and provide education of 'equal quality' for all population groups' (Chisholm, 1984: 389). This did not, however, mean equal education. A 1983 Government White Paper still defined education as the responsibility of each of the population groups falling under the tri-cameral constitution for Whites, Coloureds and Indians with education considered as one of each of these groups' 'own affairs' (Hofmeyer and Buckland, 1992). Learners from these three population groups were taught using different geography curricula. The education of Black pupils was regarded as a 'general affair' falling under the White-dominated parliament and administered by the DET which developed yet another curriculum for each subject, including Geography.

While free state education had long been available up to matric for Whites, Chisholm (1984) noted that, for the first time, free basic education for Black pupils was recommended but this was only for primary school education up to approximately twelve years of age. Post-basic education would be state funded for those following vocational/technical training but Black parents would have to fund their children's schooling if they chose an academic option, the option more likely to include Geography. Nevertheless, a provisioning programme aimed at improving education for non-White learners followed, this included the building of schools and colleges and improvements in teacher training (Hofmeyer and Buckland, 1992).

From 1985 Geography became compulsory up to the ninth year of schooling for White pupils and was then offered as an elective subject for matric. The syllabus objectives were devised to impart geographical knowledge, develop geographical skills, improve perception of the environment and encourage appraisal of actions that impact on the environment. The skills to be developed were oracy, literacy, numeracy, graphicacy and fieldwork techniques. It was noted that graphicacy and interpretation skills are both developed by map work, which 'should be integrated with every section of the syllabus' (Transvaal Education Department Syllabus, 1983: 10). While Geography was not compulsory for the other race groups up to the ninth school year, it remained an elective for the last three years of schooling - in those schools where the subject was offered.

Table 1. Comparative education statistics 1989 (after Hofmeyer and Buckland, 1992: 22)

| | **White Education** | **Indian Education** | **Coloured Education** | **Black Education** |
|---|---|---|---|---|
| Pupil-teacher ratio | 17:1 | 20:1 | 23:1 | 38:1 |
| Under-qualified teachers* | 0 % | 2 % | 45 % | 52 % |
| Per capita expenditure | R 3 082.00 | R 2 227.01 | R 1 359.78 | R 764.73 |
| Matric pass rate | 96.0 % | 93.6 % | 72.7 % | 40.7 % |

*Qualified teachers have 12 years of schooling with a 3-year teaching certificate

By 1989 the deprivation of decades of apartheid education could still clearly be seen (Table 1). The high pupil-teacher ratios, high percentage of under-qualified teachers and low per-capita expenditure on Black learners clearly accounts for the low matric pass rates. These factors are compounded for geography learners because of the mathematical nature of the skills associated with map use which had long been under-instructed and the lack of teaching resources.

Internationally, threats to the status of Geography had led to serious reconsideration of its role, especially in education. The Commission on Geographical Education (IGU, 1992) issued the *International Charter on Geographical Education*, which demonstrated how the subject contributes to individual education, international education and environmental/development education with a strong emphasis on knowledge and skills related to place and related spatial issues. South African syllabus revisions in the 1990's were guided by this report.

Turner (1993) noted that, while 70 % of matric geography candidates in 1970 were White, by 1992 70 % were Black. The geography curriculum in use in the early 1990s was considered to be irrelevant for many learners of colour because it had been developed in a 'white- and male-dominated process which had been non-participatory for the majority of role players' (Kriel, 1993: 14). Despite the fact that South African education (with its differentiated curricula, administration and teacher training) was regarded as lacking political legitimacy, the popularity of Geography as a school subject continued to increase amongst Black learners (Conacher, 1993). On the eve of the first democratic elections in South Africa it was imperative to instil new faith in an education system that would serve the needs of a politically free South Africa. Not only was it necessary to change the fundamental structure of South African education, it was necessary to keep Geography education up to date with world trends.

The rapid increase in people of all races attaining matric results that qualified them for university entrance resulted in a burgeoning demand for places in tertiary education institutions. The Nationalist Government had established Vista University in 1981. The building of campuses close to segregated residential areas reserved under apartheid for Black people (e.g. in Daveyton, Mamelodi, Sebokeng and Soweto) was an attempt to ensure that those seeking tertiary education would be accommodated locally, rather than on campuses previously reserved for other population groups. Vista University's Distance Education Campus (VUDEC) attracted a significant number of practicing teachers who needed to upgrade their qualifications before they could progress onto the newly devised salary scales for state schools. Previously, Black teachers were considered qualified after only ten years of schooling plus a two year teaching certificate. This amounted to three years less training than was acceptable for White teachers and accounts for the high percentage of under-qualified teachers in the last two columns of Table 1.

It was while tutoring teachers registered with VUDEC for correspondence courses in Geography (between 1983 and 1991) that the author first became aware of the inadequate resources available in schools previously administered by the DET. Many had never seen an example of a topographic map sheet and certainly had never seen their local topographic map. They were unaware of the existence of South Africa's national mapping organisation (NMO) and still viewed the introduction of the practical paper to assess map skills with fear and resentment. One reason for the latter was that Black residential areas were often not shown on maps (Pateni, 1997). For many years, Geography teachers on the periphery ignored the injunction to teach map skills. Instead they encouraged their matric candidates to guess the answers to the practical exam paper which consisted solely of questions with multiple choice answers (one correct option and only two distracters). It is as a result of many factors that the spatial competence of Black school leavers, even those with Geography, was poor.

## 3. Post Apartheid Geography Education

It was not only geography education that changed after 1994; the Geography of South Africa changed fundamentally. Within the national boundary, the original borders of the Transvaal, Natal, Orange Free State and Cape Province had been redrawn over the years to implement the apartheid policies of the Nationalist Government, making way for various homelands and so called 'independent states'. After the fall of apartheid, new boundaries were drawn to produce nine provinces. How geography education reform has played out against this changed political background is traced in this section.

### 3.1 The First Wave of Education Reform: Curriculum 2000 for General Education and Training (GET)

South Africa's 1994 elections saw the dissolution of the four provinces, the tri-cameral parliament and the infamous policies of the DET. The country was divided into nine provinces reincorporating Transkei, Bophuthatswana, Venda and Ciskei (formerly known as the TBVC states) and various other areas formerly designated as homelands. Although education provision became the responsibility of each province, it took some time to dismantle the various examining authorities that had previously existed and to implement new policies dictating that children of all race groups should have equal access to equitable education. Starting in 1996 all school leavers, irrespective of race, wrote the same school-leaving matriculation examinations set by each of the nine Provincial Education Departments (Le Grange and Beets, 2005). Two years later, Liebenberg (1998) reported that the geographical skills of first year Black students at South Africa's largest correspondence university fell far short of the standard achieved by learners of other race groups.

The new outcomes based education (OBE) policies of the post-apartheid government were developed in two phases. The General Education and Training National Curriculum Statement 2000 (GET NCS 2000) was devised for Grades R (reception year) to Grade 9. When the curriculum documents were released, serious concerns were expressed that Geography was so fragmented in the Senior Phase (Grades 7 to 9) as to be unrecognisable. Some Physical Geography concepts were moved into the Natural Science Learning Area and some of the Human Geography concepts had been bundled with history and citizenship topics into the Human and Social Sciences Learning Area. There was no reference to the development of geographical skills and techniques and this cohort of learners went up to Further Education and Training (FET) level without the benefit of a spatial skills foundation.

Following the assessment system introduced in the 1970s, the candidates who chose Geography as a matric subject wrote two examination papers. The geography theory paper tested content knowledge, the practical paper assessed their map skills (or spatial competence). Those who aspired to university entrance, attempted their examinations on Higher Grade in their six selected subjects; those entering the workplace, with or without vocational training, usually wrote the Standard Grade examinations. The scores for the Higher Grade Geography practical paper for the period 2000 to 2007 were used to assess the spatial competence of South African school leavers who had studied Geography.

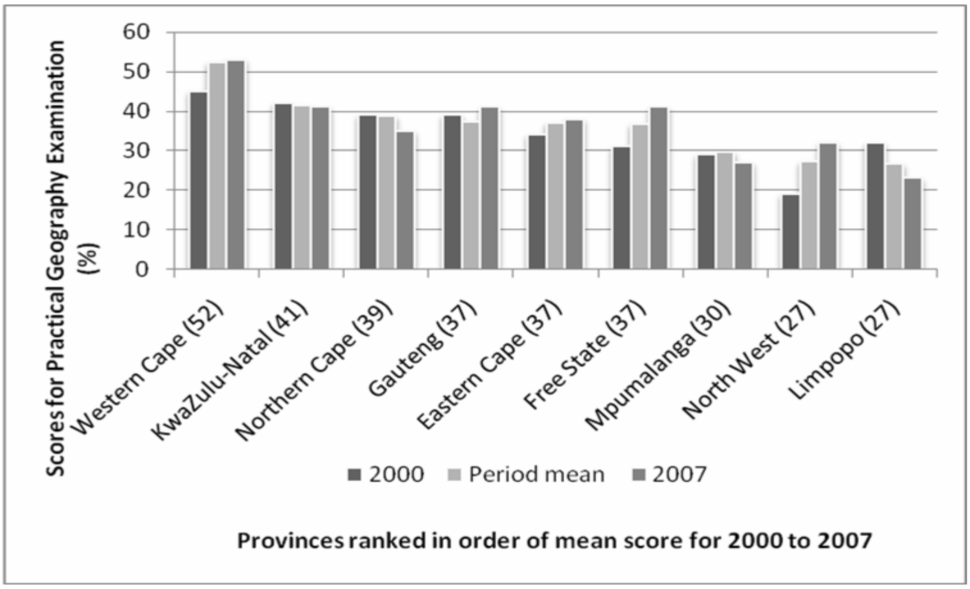



Figure 1. Mean provincial scores for the matric geography practical examination paper (in brackets) plus mean scores for the beginning and end of the eight year data period (from Innes, 2009: 27). The data were supplied by the State Information Technology Agency (SITA).

The pooled mean annual scores from 2000 to 2007 for the practical paper for each province are plotted in rank order (highest to lowest) in Figure 1 with the mean scores from 2000 and 2007 plotted on either side. From this simplistic representation of the data it is clear that in only one province, Western Cape, were average scores above 50 %. The 2007 mean score was higher than 2000 which indicated an improving trend in this province as well as in Gauteng, Eastern Cape, Free State and North West. KwaZulu-Natal scores remained almost consistent for the period unlike the scores for Northern Cape, Mpumalanga and Limpopo which showed a decline between 2000 and 2007.

While the improving trends in some provinces were encouraging, the fact that only one province had a mean score above 50 %, one had a mean score of 41 %, four had scores between 30 % and 40 % and three had scores below 30 % indicated poor results overall. These scores highlight the wide disparity between what the examiners expected learners to be able to do, using maps and other spatial information, and what they were actually capable of doing. The fact that these results were for the Higher Grade candidates confirmed that there was a widespread spatial competence problem among school leavers in South Africa. The Standard Grade scores were much lower. Students without matric Geography would not have been exposed to map study at school.

### 3.2 Second Wave of Education Reform: Curriculum 2005 for GET and FET

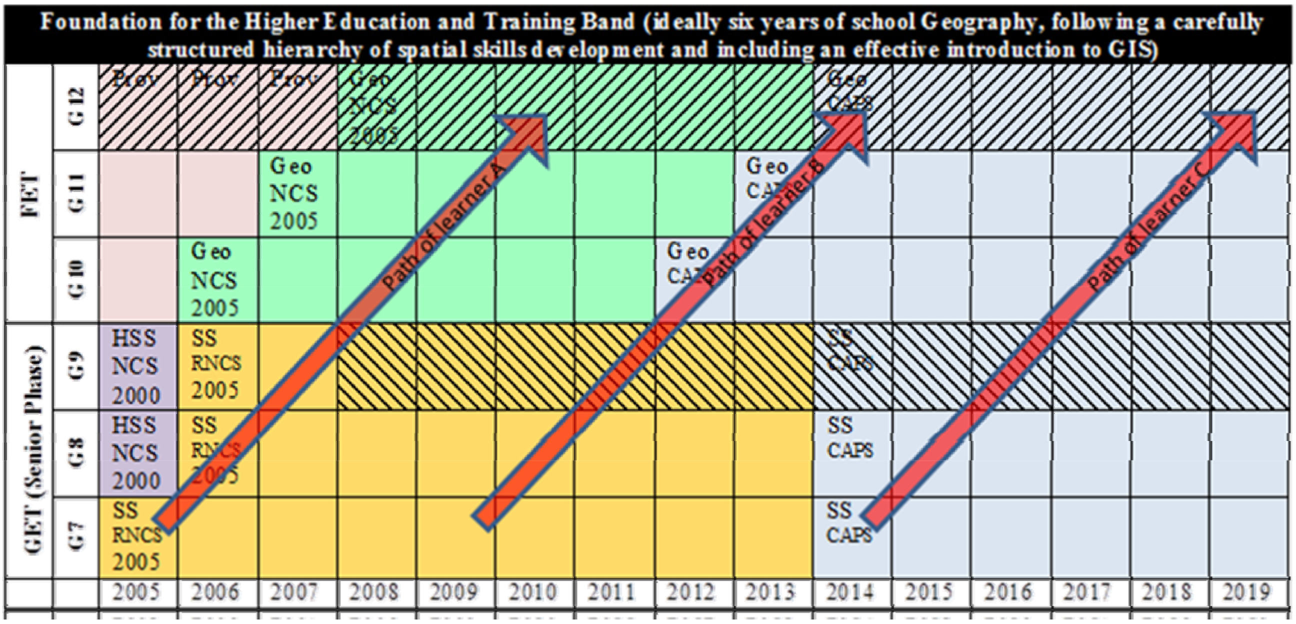
While a new curriculum for the FET Band was still under construction, it became necessary to review Curriculum 2000 for the GET Band. When the new curriculum policy document was released in 2005, both bands were included.

Thanks to a few vociferous and deeply concerned geographers, Geography and History had been disentangled and reformulated as individual topics, carrying equal weight, within the newly named Social Sciences Learning Area developed for Grades 4 to 6 in the Intermediate Phase and Grades 7 to 9 in the Senior Phase of the GET Band. Physical Geography topics such as weather, climate and geomorphology were reclaimed from Natural Sciences. When the Revised National Curriculum Statement (RNCS) for Grades R to 9 was released for implementation from 2005 onwards, geographical skills and techniques were again specified and map study was, for the first time, prescribed for examination at GET level (DoE, 2002b). Topographic maps were specifically mentioned as one of the types of maps to be used and strong emphasis was placed on investigating local issues using fieldwork.

From 2000 to 2005 there had been no prescribed introductory exposure to map skills in GET classrooms, leaving learners unprepared for the more advanced skills expected of geography learners at FET level. The new 2005 curriculum had the potential to improve the spatial competence of learners before they entered the FET band. Furthermore, the examination at the end of Grade 9 was to specifically include the assessment of map skills. However, Figure 2 shows how many years it takes before the introduction of a curriculum change in Grade 7 impacts on the improved competence of school leavers at the end of Grade 12.

While the earlier introduction of the matric Practical Examination paper (in the 1970s) ensured that school-leavers with Geography would receive map skills instruction, the implementation of RNCS 2005 made provision to equip all learners with basic spatial skills by the end of the GET Band (whether they elected to take Geography to matric or not). Including GIS in Geography in the FET Band was the first step towards laying a foundation for the technologically empowered spatial competence of school leavers.

Figure 2 illustrates the curriculum changes, the first of these significant developments was the implementation of the RNCS in the GET Band in Grade 7 in 2005 (DoE, 2002a). The arrow labelled 'Path of learner A' highlights the six year lag time between implementing a new curriculum and the time of potential impact on improved school-leaver competence. In 2006 the RNCS was implemented in both Grades 8 and 9. A new National Curriculum Statement for Grades 10 to 12 (General) Geography (DoE, 2003) was introduced at FET level in Grade 10 in the same year. This was followed by Grade 11 in 2007 and Grade 12 in 2008. The post-apartheid government's reforms initiated a common national school-leaving examination for all learners in Grade 12 in 2008. The distinction between provincial and racial differences in education policies were a thing of the past. Whether differences in performance remain, requires further investigation.




Key to shading and abbreviations marking the introduction of each phase of curriculum change

| | | | |
|---|---|---|---|
| Geo | Geography | GET | General Education and Training Band (Senior Phase covers Grades 7-9) |
| Prov | Provincial curricula (different matric examination papers in each province) | FET | Further Education and Training Band (Grades 10 to 12) |
| HSS NCS 2000 | Human and Social Sciences (Learning Area), National Curriculum Statement introduced in 2000 | Geo NCS 2005 | National Curriculum Statement for Geography implemented at FET level in 2005 |
| SS RNCS 2005 | Social Sciences, Revised National Curriculum Statement introduced in 2005 | CAPS (SS and Geo) | Curriculum and Assessment Policy Statement for implementation at GET and FET levels starting in 2012 |
| | External examination | | Internal examination |

Figure 2 Timing of curriculum change and its potential impact on matric geography results

A search through the Learning Outcomes and Assessment Standards in the *NCS for Geography Grades 10 to 12* (DoE, 2003) for the last three years of secondary school revealed little that could be used to identify a clear hierarchy of spatial competence outcomes. Although the term 'sources' (covering globes, different types of maps, models and other teaching resources for Geography) was used repeatedly, only two specific references to maps were made with no reference to other spatial information products such as aerial photographs or satellite images. While teachers with adequate training and experience would no doubt have such 'sources', new or inadequately trained teachers with little experience or exposure to maps, are unlikely to have relevant 'sources' or know how to access or use them.

The two official documents, long awaited by teachers for assistance with implementation of the NCS, the *Learning Programme Guidelines (LPG)* (DoE, 2008a) and *Subject Assessment Guidelines (SAG)* (DoE, 2008b) contradicted each other on the topic of spatial competence. They provided scant assistance in the development of a graduated programme of map analysis skills acquisition (Innes, 2005). While there was ample evidence that map use had been given a central place within

Geography, and that maps were to be used to investigate real issues in local contexts that had impact on learners' lives (IGU CGE, 1992), guidance on what map use techniques should be introduced when, and at what skill level, was not given. There was no clear definition of spatial competence nor was there a hierarchy for introducing map skills in a way that would help learners move from simple to more complicated tasks, gaining confidence as they progressed, as recommended by many authors from Alexander and Blanchard (1985) to Wiegand (2006).

Introduction of GIS into the Geographical Skills and Techniques section that had long been examined by the Practical Examination Paper was a brave step forward. There was a far greater degree of progression of GIS concepts, compared with map use concepts, in the *SAG's* Content Framework for Geography (DoE, 2008b: 21 and 22). Unfortunately, when it came to the examples of Work Schedules across the three Grades in the *LPG* (DoE, 2008a: 35 - 45), only some of the GIS concepts had been itemised in Grades 10 and 11 while none of the Grade 12 GIS content appeared in the Grade 12 Work Schedule. This fuelled rumours speculating on the future of GIS which had stirred mixed reactions when the NCS for FET was introduced into classrooms for the first time in 2006. It was seen by many as a volatile link between paper-based map study (which had long been under-instructed in many schools) and the information technology (IT) resources that were then not available for teaching in the majority of South African high schools.

### 3.3 Third Wave of Education Reform: Curriculum and Assessment Policy Statement (2011)

Dissatisfaction was expressed at the onerous burden of assessment linked with OBE and the confusion caused by the plethora of contradicting documentation. This led to a further review process of both the *RNCS for Grades R to 9* and the *NCS for Grades 10 to 12*. The drafting of the Curriculum and Assessment Policy Statements (CAPS) was initiated in 2009 by the new Department of Basic Education (which had formerly been part of the Department of Education responsible for General, Further and Higher Education and Training). The CAPS document will eventually replace the *RNCS*, *NCS*, *LPG, SAG* and other related documents. Public participation in compiling this document was invited. A first draft was circulated and again public comments were invited. A final draft of the CAPS document was provided to the Publishers Association of South Africa early in 2011 to facilitate preparation of textbooks (DBE, 2011a). A process of implementation starting in 2012 had already been announced by the Director-General of the Department of Basic Education (DBE, 2010) but changes to the implementation dates occurred by the time it was gazetted (DBE, 2011b).

Positive developments at GET level include the clearer map skills hierarchy developed sequentially right from the Intermediate Phase (Grades 4 to 6) into the Senior Phase (Grades 7 to 9). Guidelines for topographic and orthophoto map study are clearly spelled out with reference to the resources available from the NMO. Once the CAPS are implemented, the Social Science teachers are trained and the resources are provided, all learners reaching the end of the GET Phase should be well equipped to use maps with confidence in the internal school examinations (Figure 2).

At FET level, positive developments include the integration of map skills with content and a less onerous introduction to GIS concepts in Grade 10. The previously implied reliance on using IT to teach GIS has been clarified by reference to the use of tracing paper to capture data in Grade 11 and to build a 'paper' GIS with layers of information in Grade 12 (DBE, 2011a: 24 & 34).

Once learners have received the improved spatial competence education provided for in the CAPS for GET level, they will progress to FET level with an established skills base from which to develop advanced spatial skills. But, the timing of policy implementation is unfortunate. The CAPS have been implemented for Grade 10 starting in January 2012 but the learners have not received the spatial skills foundation provided for in the improved curriculum for Grade 9 (see the arrow marking the path of Learner B in Figure 2). While the CAPS implementation date for Grades 7 to 9 was initially planned for 2013 (DBE, 2010), it has been deferred by another year to 2014 (DBE, 2011b). This means that it will be 2019 before those leaving school will be fully supported by the effective implementation of a six year Geography curriculum that promises improved spatial competence from Grade 7 through to Grade 12 (see the arrow indicating 'Path of learner C' in Figure 2).

## 4. Preparing and Provisioning Teachers to Develop Geospatial Competence

The success of a new initiative in education depends on many factors (Fullan, 1995). It is especially complex when the change includes the introduction of information and communication technology (Matengu, 2006). In reviewing school Geography's potential to underpin the foundation for geospatial competence at tertiary level, two factors are briefly addressed: geography teachers and available resources.

### 4.1 Geography Teachers

When Geography was first introduced as an academic discipline at tertiary level in the Cape Colony in 1916, the majority of students were teachers in training (Clark, 1989). This is no longer the case as the number of practising geography teachers in South Africa is declining rapidly (Fairhurst et al., 2003). Although no formal survey has been conducted, in conversation with geography lecturers at the Universities of the Witwatersrand, Cape Town and Western Cape all agreed that the number of geography students studying to become teachers has decreased steadily in recent years. A small light at the end of the tunnel is that Geography has been placed on the priority subject list for the Department of Basic Education's Funza Lushaka Bursaries (DBE, 2011c) in order to attract potential geography student teachers back into the profession.

A serious challenge at GET level is that the Social Sciences Learning Area which covers History and Geography is, more often than not, taught by history teachers who are unlikely to have had specific map use training. Just when the importance of spatial thinking is being acknowledged and the value of GIS for enabling such thinking clearly understood (NRC, 2006), it is ironic that the teachers who are required to nurture this competence are being attracted away from the teaching profession and joining new geography graduates in the wide range of positions opening up in municipal and provincial administrations and environmental agencies (Fairhurst et al., 2003) and more recently in utility companies and in the geospatial and related services industries.

An opinion survey was conducted in 2000 with 178 senior geography educators at underperforming schools to establish whether they felt adequately prepared and resourced to teach map skills. Only 56 % were confident of their own map skills and 90 % believed these could be improved by using a basic topographic map reading programme (Innes, 2002). In a more recent attempt at the collaborative writing of topographic map analysis exercises, 70 % of the questions written by a group of 108 practicing senior geography teachers were rejected because they were inappropriate or the answers they had provided to their own questions were incorrect (Innes, 2009). The types of errors made by teachers in the learning and teaching support material (LTSM) collaborative writing attempt suggested that many teachers were not familiar with cartographic terminology, or with acceptable levels of mathematical accuracy or with the appropriate sequencing of skills in the map reading-analysis-interpretation hierarchy.

Naish (1982), Lambert (2002), Wiegand (2006b) and others have shown that the teaching methods required for spatial skills development are more specialised than methods used to teach Geography content. Castner (2002 a & b) decries the tendency of geography teachers to shy away from engaging in the mathematical analysis of spatial information. Mathematical competence, shown to impact positively on map analysis skills (Innes, 2003), was seriously compromised by apartheid education policies which limited the scope and depth of subjects, especially Mathematics, offered by the DET. Fortunately new education policies provide for instruction in Mathematics or Mathematical Literacy for all school leavers.

Because of its complexity, the language used to teach geography is particularly important (Butt, 2002), especially when dealing with spatial concepts, techniques and skills. However, the majority of South African teachers are not teaching in the home language of their learners or their own home language; a matter requiring serious attention in the attempt to improve the spatial competence of school leavers.

### 4.2 Resources Required: From Maps on Paper to Maps on Screen

It is impossible to teach someone to read a map if there are no maps to read. The majority of schools responding to the survey mentioned in 4.1 were under-resourced, 78 % of the 178 respondents indicated that they lacked adequate resources for teaching map use (Innes, 2002). In an attempt to provide access to local maps, the MapPack Project of the Chief Directorate: National Geospatial Information (CD:NGI, the new name of the NMO) provides free maps of their local area to schools and offers training to teachers in using maps to teach Geography (Innes and Engel, 2001 a & b). Unfortunately, the offer of training is taken up by only a small number of schools each year.

While policies are in place to promote the use of IT in education (Howie et al*.,* 2005) there is still no national rollout of resources that make the use of GIS in geography education available to all learners. Opinions differ widely on whether GIS should be in the curriculum at all. Indeed, in some areas, where there is a high percentage of under-resourced schools, Geography as a school subject at FET level is under threat precisely *because* of the decision to include GIS in the geography curriculum. In some areas (notably in the Free State) Geography has been withdrawn from the subject offering at some schools, the main reason given was teachers' unwillingness to engage with the technology (S Neuhoff - provincial geography examiner, Free State - personal communication, 2006). Negativity was recently summed up as follows: 'GIS is tearing Geography asunder' (Mini, 2011). Mini also claimed that this is partly due to the attempted commercialisation of GIS in schools.

The low levels of spatial competence amongst those geography teachers in under-resourced urban and rural schools (which make up the majority of the almost 6 000 high schools in South Africa) is only one reason for their resistance to GIS in the curriculum. Another reason is lack of access to the necessary hardware and software required to teach GIS effectively. In a unique pilot study in the Western Cape, Carolissen et al. (2006) reported that when 25 schools where given GIS software and the necessary IT resources, the teachers participated willingly in the training. On the other hand, Olivier (2005) described the excitement of learners at an off-site demonstration of GIS in the Eastern Cape and compared this to the disinterest of teachers, citing the abysmal situation in schools regarding lack of IT facilities.

At the opposite end of the spectrum are the minority of select state and private schools where the parents fund high levels of school staffing and resources. Here, sophisticated technology is seen as an opportunity and not a threat. Software and hardware are made available and used with confidence to enhance learning. Well paid and thus well motivated teachers have come to grips with the technology and use it confidently in their digitally live and enabled classrooms. At a recent demonstration of Google Maps functionality for plotting and capturing fieldtrip data, the presenter said that pupils were justified in considering their geography teachers illiterate if they did not use Google in their geography lessons (Lanser, 2011).

Well equipped teachers have realised the potential of GIS for enhancing geographic understanding (Fitzpatrick and Maguire, 2001; Forster et al., 2007; Bednarz and Bednarz, 2008 and many others) but tend to forget their privileged status when urging adoption of GIS in all schools. The disparity between the haves and the have-nots in South African education could not be starker than in the utilisation of IT particularly in the implementation of geospatial technology in geography classrooms.

In cases where some IT facilities are in place in schools, the main emphasis is currently on mathematics instruction with science and language support also receiving attention. However, Lundall and Howell (2000) cited the following as factors preventing widespread computer use in South African education: insufficient funds, too few computers, lack of computer literacy among teachers, lack of computer-trained subject teachers and the absence of a computer skills curriculum. Lack of awareness of the requirements for using GIS in Geography is suggested by the paucity of information on GIS in their guide to managing ICT for South African school principals (Bialobrzeska and Cohen, 2005). The situation is not unique to African countries. It was initially reported that low levels of adoption of GIS in American schools could be attributed to limited access to hardware and software in schools, intimidating software, insufficient time available for learning to use the software and low levels of technology training for teachers (NRC, 2006).

The factors that promote or impede the use of information communication technology (ICT) in schools have been investigated in Namibia. The findings of Matengu (2006) may have relevance for the likelihood of adoption of GIS in South African schools. He found that apart from changing political agendas related to development, a perceived need for technology by education officials was an important promotional factor. To counter this, the impeding factors included: inequalities between core and peripheral areas, lack of infrastructure, inadequately devised adoption strategies and lack of vision and guidance from policy makers.

Carolissen et al., (2006) reported that after getting training from two different service providers (ArcView® 3.3 supplied by GIMS and a locally developed inter-curricular GIS programme called Geomatica supplied by Naperian GIS Technologies) teachers at 25 Western Cape schools were asked to evaluate both software packages and recommend one of them for implementation throughout the province. Teachers perceived that the training was concentrated on mapping applications and not on the theory and principles underlying GIS as prescribed in the curriculum. Despite the fact that teachers felt that their choice of software was ill-informed because they were still getting to know about GIS, the tender for installing ArcView® 3.3 in all high schools, offering Geography to Grade 12, in the Western Cape was awarded to GIMS (Rust and Kindler, 2008).

Although reports on the implementation of GIS in the other provinces have not yet come to hand, investigations into computers in schools have. According to the findings of Lundall and Howell (2000), only about 10 % of the almost 28 000 schools in South Africa (both primary and high schools) had computers at the start of the millennium. Over time, the situation has improved to about 13 % with the majority of computer using schools in the Western Cape and Gauteng '... and it is no co-incidence that they are also the two wealthiest provinces ...' (Howie et al*.,* 2005: 109). GISSA members have been pro-active in supporting GIS education in different provinces in South Africa (Roos, 2011). The Western Cape Branch has been particularly active by promoting and supporting GIS Week which has grown from strength to strength over the last 8 years.

Many teaching methods can be applied in teaching spatial competence, all require specialised resources. In South Africa Tshibalo (2003) reported improved scores for cooperative map use activities conducted in groups. Self-instruction has been evaluated as a method for improving spatial competence for topographic map reading (Innes, 1989). Three possible approaches have been identified for teaching GIS: teach about GIS, teach map skills using a GIS platform (Innes, 2009) and teach geographic concepts using GIS. There is a clear division between these approaches and the line is not drawn strictly between the technologically advanced first world and less advanced third world. Green (2001) suggests that, as software and hardware become increasingly user-friendly with better manuals and the fact that children readily adapt to a computer environment, GIS can be grasped by any geography teacher. While this may be true in a well resourced school setting, for those teachers who are less computer literate or for whom there is no access to computers, GIS is not an easy option. Even in a developed world setting, Kerski (2003) reported that fewer than 8 % of American high schools had purchased GIS software, only half the educators at those schools were using it and, of those, only 20 % used GIS in more than one lesson with more than one class.

Forster et al. (2007) reported that an ambitious GIS in Education project was to be launched in Rwanda in 2008. In a collaborative effort between the Centre for GIS and Remote Sensing of the National University of Rwanda (CGIS-NUR), Kigali Institute of Education, Rwandan Ministry of

Education and using licenses donated by Jack Dangermond of ESRI, trained teachers at ten pilot senior secondary schools started using GIS in their teaching and also trained teachers from three selected surrounding schools. The roll-out programme will repeat the 'snowball effect' with each newly trained teacher training three more each year. The progress of this project is being watched with great interest. During the third ESRI Summer Camp in Africa, scholars trialled procedures for the 2012 national census in Rwanda with great success (ArcGIS, 2011).

In cases where successful implementation of GIS in education has been achieved, it has generally been where local spatial data has been imported and learners were encouraged to undertake GIS enabled investigations with local relevance in their home areas (Fitzpatrick and Maguire, 2001; Maguire, 2006; Wiegand, 2006 a & b). A local example is Ashwell's (2007) report on a successful GIS project supporting biome studies in Biology that involved youth groups in gathering and plotting bird data in urban nature reserves in Cape Town.

After examining the reasons why the potential of geospatial technologies (GST) including GIS, for enhancing spatial learning were not being met in many countries, Bednarz and Bednarz (2008) developed and instituted the Advancing Geospatial Skills in Science and Social Science (AGSSS) programme. They identified the most significant barriers to diffusion of GST as first teachers' lack of understanding of the cognitive skills underlying the application of these technologies and second their failure to understand the importance of spatial thinking. By addressing teachers' need for knowledge, preliminary findings indicated that the programme was successful in recognising: that educational change takes time even with considerable support; that some knowledge aspects are assimilated quicker than others and that spatial vocabulary and concept understanding are key to spatial thinking.

## 5. Conclusion

Research indicates that the introduction of GIS at school level has the potential to improve spatial competence but GIS is not just another teaching resource that can be added to the geography classroom like a globe, wall map or personal computer linked to digital projector. The advancement of spatial thinking and the development of the geospatial technologies that have both inspired and stimulated spatial thinking (NRC, 2006), have the potential to completely revolutionise teaching in, for and about the world. In South Africa, it is only in the geography classroom that this potential can be realised.

It is unfortunate that in the past, school Geography has been undervalued by tertiary education institutions offering courses in geospatial technology. Mathematics and Physical Science are prerequisite matric subjects while Geography, the only school subject that provides learners with a broad geographic concept framework and a basic spatial skill set including an introduction to GIS, is ignored. This can be better understood in the light of the foregoing discussion. However, the time is now right to change attitudes towards school geography. It is not suggested that Geography should replace either Mathematics or Physical Science as prerequisite matric subjects, it is suggested that Geography should be listed alongside them as a recommended matric subject for courses in geospatial technology. This would both meet the pressing need for finding geospatial students and trainees with at least some basic spatial competence and would simultaneously improve the status of school Geography. The improved status would in turn provide leverage for accessing funding for better teacher training and resourcing of geography classrooms.

It has been shown that improvements in the spatial competence of school leavers with Geography can eventually be expected. Towards this end, policies are in place, some teachers are willing, many learners are striving and vendors are supplying resources. The efforts of secondary and tertiary education institutions must be co-ordinated to maximise the potential of the education policies that are now in place to ensure that school geography in South Africa underpins the foundation of geospatial competence upon which tertiary education and ultimately the geospatial information industry depend.

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