An Investigation into Educators' Rraining in Geographic Information Systems

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***Abstract*—An investigation is undertaken into the training of educators in Geographic Information Systems (GIS) within a South African context. Educators not being familiar with GIS requires development platforms to be created. One such platform is the short learning programme (SLP) hosted by the University of Johannesburg, which is used as a point of focus for this study. It was found that barriers experienced by educators in the implementation of GIS within their classes are similar to those experienced in countries such as Japan and Taiwan. Teachers lack the skills and knowledge in GIS and respondents identified this as the main reason for attending the SLP. The effectiveness and shortcomings of the SLP is also investigated in order to incorporated this feedback into future training of teachers. This paper contributes towards the development of the training of geography educators in South Africa.**

***Index Terms*—GIS, geography, educators, teacher training, Gauteng, University of Johannesburg, South Africa**

I. Introduction

The importance and potential of Geographic Information Systems (GIS) as a field within geography, was recognised by the South African Department of Basic Education (DBE) when it was included within the geography syllabus of the Curriculum and Assessment Policy Statements (CAPS) curriculum [1]. The CAPS forms part of the DBE's National Curriculum Statement and is utilised by the country's government schools [2]. The DBE included GIS as one of the nine aims for the Geography syllabus for the Further Education and Training (FET) Phase (Grades 10-12). This aim is to promote "the use of new technologies, such as Information Communication Technology (ICT) and Geographical Information Systems (GIS)" [1].

Diagnostic reports of the national final examination indicate that the fundamental knowledge of GIS is lacking amongst teachers and that they are not familiar with GIS. Due to this skill shortage of teachers in the FET band in geography, the Gauteng Department of Education (GDE) and the Education and Training Practices Sector Education and Training Authority (EDTP SETA) requested the University of Johannesburg to train teachers in GIS. In 2014, 52 teachers were trained in GIS as a pilot project. The purpose of this study is to determine if the skills of teachers in GIS improved and their views on GIS in the classroom.

II. Literature Review

Researchers identified that teachers recognize the importance of GIS as an educational tool [3]. Reference [3] states that teachers who are utilising GIS within their classes are positive and enthusiastic towards the use of it within their classes. However, it is also found that particularly within the United States of America (USA) that teachers who are utilising GIS in their classes are often using different materials to teach their classes with [3]. The fact that educators have a varied understanding of GIS and thus approach the subject matter differently is an important factor that must be taken into consideration [3]. The GIS has become popular as a technology, as a tool within academia and at a secondary school level. Therefore, training programmes for teachers that focus on the use of GIS and the teaching of/about GIS are important. It is important to ensure that training programmes are a success, and implemented properly in conjunction with a respective country's curriculums for geography and other subjects in which GIS is utilised within.

The use of GIS within education in South Africa has, until recently, been centred within the realms of tertiary education institutions. The majority of South African universities offer a degree/diploma in GIS or include it within related degrees/diplomas [4]. The Geographic Information Society of South Africa (GISSA) was formed in 2000, and has since undertaken projects to establish a geographic information unit standard for South Africa, as well as the standardization of geographic information science qualifications. This has many direct and indirect benefits to the growth and development of GIS within South Africa, particularly in encouraging the discipline to be chosen as a career path by students.

However, within South Africa the implementation of GIS into the national curriculum has been notably slow. The curriculum for GIS was initially introduced for Grade 10 in 2006; Grade 11 in 2007 and for Grade 12 (known as matric) students in 2008 [5]. These three years for the implementation of GIS as part of the geography syllabus was done in such a manner that the grade 10 students of 2006 were the first to complete all three syllabi that contain GIS within the geography syllabus for the three senior grades.

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South Africa faces similar challenges and problems as countries like Taiwan [6] in terms of successfully implementing GIS into its national curriculum. Three challenges in South Africa, which are vague in nature, have been identified by reference [5]. These are: money; support and time. The lack of capital is the largest obstacle to the successful implementation of GIS in schools in South Africa. It is widely accepted that the implementation of any GIS system into a school requires a high quantity of capital, which is a important factor when considering the severe inequality that exists in South Africa as a result of the country's political past. This resulted in the infrastructure and resources available to schools being of two extremes [5], [7]. Three support levels are required if the implementation of GIS is to be successful within a school setting in South Africa [5]. The three levels of support necessary are: firstly, the support from school leaders and the school community; secondly the support from local tertiary institutions which offer education programs for teachers and lastly, the support from government and industry [5]. Research identified time constraints and the lack of time as the biggest obstacle to implementing GIS in a classroom environment [3], [5], [6].

In South Africa "teachers are the largest single occupational group and profession in the country, numbering close to 390 000 in public and private schools" [8]. It is thus necessary to examine how geography teachers/educators continue their training to keep up to date in their teaching techniques and the use of new technologies such as GIS.

A. Training of Educators in South Africa

In 2013, South Arica had 6 098 secondary schools with 3 895 909 learners and 143 862 educators, with a national average learner-educator ratio of 29.4:1 [9]. In 2015 a total of 303 985 learners wrote the geography paper in the matric examination and only 153 212 (50.4%) of learners achieved 40% and above [10]. It must be noted that 30% is considered a 'pass' in the South African matric examination. Furthermore, it was reported in the media that the national average for Geography in the 2016 matric examination was 39% [11].

The abovementioned statistics and figures give context to the current geography teaching landscape within South Africa. There are two main teaching qualifications recognised towards becoming a qualified secondary school teacher in South Africa. These are the four-year Bachelor of Education (BEd) degree, as well as the Advanced Diploma in Education [8]. Once individuals completed one of these qualifications, they can register as a teacher with the South African Council for Educators (SACE), allowing them to practice as a professional teacher. Once teachers are qualified and teaching, it is expected of them to continue increasing their knowledge of subject matter in their subjects, known as Continuing Professional Teaching Development (CPTD).

Within a new system that SACE is responsible for, a professional development (PD) points system is utilised to acknowledge educators' continual professional development. Each teacher is expected to earn PD points, by attending professional development programmes or courses appropriate to their own teaching field and that are recognized by SACE [8]. The DBE established a unit that monitors the quality of teachers registered with the SACE. This unit is the National Education Evaluation and Development (NEED) unit. The unit monitors the performance of teachers in the country, as well as manages the Integrated Quality Management System created for the appraisal of teachers [8].

The PD points system motivates teachers to learn how to use technical technologies such as GIS that were not initially designed to be used for educational purposes [12]. Thus, teachers will not necessarily learn how to use a GIS unless they are required to or if it forms an important part of the curriculum that they teach [12].

Within the South African educators' workforce two-thirds of teachers are within the age group of 35-50-year, 21% under the age of 40 and 5% over 55 [8]. Thus, a considerable percentage of teachers were not exposed to GIS during their studies. These teachers completed their qualification before GIS was included in curriculums of tertiary institutions, let alone within secondary school curriculums in the country. Therefore, these teachers need to be trained in how to use and apply GIS within the classroom environment. ICT and GIS technologies develop at such a rate that educators and professionals need to attend training seminars or programmes to stay up to date in these fields and to adjust the way in which they teach to the benefit of their students.

In order to gain a holistic understanding of geography educators training within South Africa, it is necessary to examine the South African National Curriculum's geography syllabus.

B. GIS in the South African Geography Syllabus

As stated before, within the CAPS FET framework for senior grades in South Africa, one of the major aims of the syllabus for geography is the following: "promoting the use of new technologies, such as Information Communication Technology (ICT) and Geographical Information Systems (GIS)" [1]. The utilisation of GIS can clearly be identified to achieve the 'four big ideas' of geography. These are: place; spatial processes; spatial distribution patterns and human and environment interaction. Mapwork is taught from Grade 4 in South African government schools, which theoretically provides the basis for GIS to be taught in the senior grades (Grades 10-12) [1].

In Grade 10, GIS is introduced to students. The following concepts of GIS form part of the curriculum: why it was and is being developed; the concepts of remote sensing are introduced along with how remote sensing works and the basics of GIS. At a Grade 11 level: the different types of data; raster and vector data and the application of GIS to relevant topics, to name a few. Lastly at a matric or Grade 12 level, students are taught GIS concepts which specifically examine remote sensing and the influence of resolution. Other aspects covered in GIS include: spatial and attribute data; data standardisation and data security; the manipulation of

data and the application of GIS by the various sectors, as well as practical applications of GIS [1].

While the constraints of this paper do not allow for the examination of the teaching of mapwork within the South African national geography curriculum, the teaching of map work and GIS should be linked. This is seen the clearest in Geography Paper 2 in the national final (matric) exams in South Africa that covers map work and GIS. What is alarming is the fact that question 4 of Geography Paper 2 of 2014 and 2015 was the question learners performed the worst in [10], [13]. This question is based on GIS and its application thereof. Within the diagnostic reports the following comment is made which gives a basis for the research: "The fundamental knowledge of GIS (Geographical Information System) is lacking. It seems as if many teachers are not familiar with GIS" [10], [13].

III. Methodology

The sample or study group comprised of 52 educators that varied from teachers from public schools within Gauteng; to members of various education boards and members from the Gauteng Department of Education. The use of questionnaires was identified as the most appropriate methodology for the data collection process.

Google Forms was used as a digital platform for data collection. However, problems were encountered during the data collection process. These problems include: the slow response time of receiving completed questionnaires; incorrect email addresses being given by educators when they attended the short learning programme; relatively low response rate (33%); and educators not being able to find the attached link to the form containing the questionnaire.

The questionnaire itself is made up of three sections. The first section of the questionnaire asks general and demographic questions, such as the age of respondents and the highest educational qualifications the respondents achieved. The second section is based on GIS in high school education and the third section is based on the implementation of GIS in high schools in South Africa. Both qualitative and quantitative based question are asked, allowing for various types of data and information to be acquired from the respondents, including opinion based answers, as well as open-ended questions.

The results from the data collection are shown and discussed in the next section.

IV. Results

The response rate obtained is sufficient to be able to identify trends and patterns in relation to the aim of this study. Firstly, examining the demographics of the study group, 63.2% of the respondents are males and the remainder females (36.8%). Within the study group none of the respondents are below the age of 30, nor were any of the respondents over the age of 60. Over two thirds of the respondents fell within the age group of 40-49 (68.4%); 21.1% of respondents fell within the age group of 30-39, and the remaining 10.5% fell within the age group of 50-59. The average amount of years that the respondents taught or been involved with geography education was 16 years, reflecting a mature and experienced study group. Additionally, 36.8% of the respondents obtained a post-graduate degree (honours/ master's degree).

42.1% of the respondents attended a course or SLP (short learning programme) in GIS before the one hosted by the University of Johannesburg (UJ). This is an encouraging sign as these teachers are continuing to develop their knowledge in GIS, as well as improve their skill levels towards utilising GIS within the classroom environment. The majority (57.9%) of the respondents attended a GIS course for the first time. The reasons for attending the SLP varied as can be seen in Table I. The most stated reason for attending the SLP was to increase their understanding and knowledge of GIS (78.9%). This may be as a result of the educators themselves not being exposed to GIS when studying for their teaching qualifications. Respondents could choose multiple options and the second and third most popular reasons are indications of educators seeking to incorporate both practical and theory components into their classes.

TABLE I. REASONS FOR ATTENDING THE GIS SLP

Reasons	Number of participants (%)
To increase knowledge and understanding of GIS	78.9
Incorporate new and interesting material into classes	52.6
To incorporate technology into classes	42.1
Recommended to by a colleague	0
Other	5.3

Attention should be paid to the fact that 94.7% of the participants of the study stated that they work at a public school or a public institution. This is particularly important within a South African context as a result of the high levels of inequality that exist within the country. A consequence of this is that public schools, especially in poorer areas, do not have access to the funding and resources required. This results in educators not having access to resources needed to teach technical content or even understand the content themselves. However, the pilot project which took place in 2014 specifically targeted senior teachers that included head of departments (HODs) of schools and subject advisors from the Gauteng Department of Education (GDE). The reason for this was that the senior teachers and advisors could aid in spreading and disseminating the knowledge taught to them. By doing so, this helps to reduce the demand for training programmes in GIS and allows for the senior teachers/educators to aid in the development of their colleagues.

Teachers attending the SLP were asked to indicate their knowledge of GIS before attending the SLP. The result, together with diagnostic reports [9], [13] that indicate teachers are not familiar with GIS, are indications that there is a need for training of teachers in

GIS. The result is illustrated in Fig. 1 where respondents were asked to rank their level of knowledge on a scale of 1-5 (with level 5 being excellent). Two thirds ranked their previous knowledge as either a 1 or a 2. Thus, 63.2% of the respondents felt they did not have a good understanding of GIS before attending the SLP.

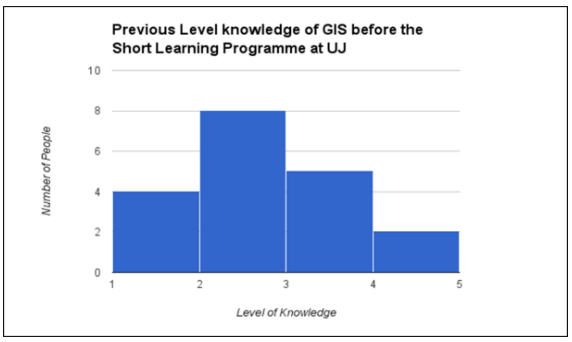

Figure 1. Previous knowledge of GIS

However, the success and execution of a training programme need to be evaluated, by examining a sample group such as the one utilised in this study. Since GIS is technical in nature, the SLP needed to be able to pay enough attention to different components of GIS. 84.2% of respondents felt the SLP had achieved this and all agreed that the programme was structured in such a way that it allowed them to clearly understand the content. As with any educational programme, there will be shortcomings and ways in which they can improve. One such area identified is the implementation of follow-up workshops for educators. Reasons given for this included the desire to gain further knowledge, improving the confidence of teachers and the need to translate knowledge into classroom situations. Two further areas of improvement were identified in the study. The first is remote sensing. Even though remote sensing was integrated throughout the course, 15.8% of respondents indicated that a section of remote sensing needs to be included. Secondly, 21.1% indicated that although the SLP addressed the need to increase knowledge of GIS, it does not necessarily address how to translate what they have learnt into the classroom environment. However, 94.7% of the respondents could apply the new knowledge that they gained into the classroom environment to the benefit of their students. This then is an indication that teachers could use the information that they were taught and are able to adapt this information to suitable scenarios within the classroom.

All the respondents felt that GIS as a tool can be used positively within the classroom. The different views of GIS as a tool is illustrated in Table II. Although respondents could choose multiple options to the question, one is still able to identify the most popular way in which educators view GIS as a tool. 84.2% of the participants regarded GIS as a tool that can be used to encourage students to interact with and question geographic information, the second most popular view was that GIS is a tool that can be used to encourage critical thinking amongst students, with 63.2%. These views of GIS then are encouraging, as it is proof that educators see real value in utilising GIS within their classes to develop skills in their students. Respondents also commented on the use of GIS in the classroom. Two comments stood out. The first is that learners jumped at the opportunity to utilise new forms of technology and that the use of technology motivates students. The second is that GIS is only forms a small percentage of the final geography paper. This respondent expressed the view that if GIS is allocated more marks, teachers would pay more attention to it and more resources would be provided for the teaching of GIS.

TABLE II. GIS AS A TOOL

GIS as a Tool	Number of participants (%)
A tool that can be used to encourage students to interact with and question geographic information	84.2
A tool that can be used in inquiry based learning scenarios and/or opportunities	36.8
A fun way for students to use technology in a learning environment	31.6
A tool that can be used to encourage critical thinking amongst students	63.2
A tool that can be used in lessons when other work has been completed	10.5
GIS is not a tool that should be used within a high school learning environment	0
Other	5.3

Regarding teachers' view on implementing GIS in high schools in South Africa', 94.7% of the respondents felt that there is a strong potential for GIS to be used in the classroom in the future. Another important factor that should be considered is whether educators are aware of curriculum requirements of GIS within the geography syllabus. Even after successful completion of the SLP, almost a third (31.6%) of teachers indicated that they have no or some idea of the curriculum requirements. This is result is a concern as these are senior teachers or subject advisors that should have a good understanding of the curriculum and GIS.

In relation to this it was found that every respondent in the study actively taught mapwork in their classes and all felt that GIS is relevant and should be taught alongside mapwork sections of the syllabus. Furthermore, 73.7% of respondents felt that the teaching of GIS should involve both practical and theory components that integrates mapwork with GIS. One respondent made the comment that GIS "is a tool that brings mapwork alive". Yet the lack of access to required resources, made teaching the practical components of GIS very limited in almost all cases. It is important to note that 84.2% of respondents felt that GIS encourages students to think in a critical manner, to question geographic data, as well as being a benefit to the students in real world scenarios.

All respondents indicated that students within their classes struggle to understand the GIS part of the syllabus. This is part due to the barriers in the implementation of

GIS within high schools within South Africa. Of interest is what educators viewed as the biggest barriers to the successful implementation of GIS in South African schools. These views and opinions are given in Table III below. It would be unusual if respondents did not identify the large financial requirements needed for GIS within the classroom as one of the biggest barriers, as identified by reference [5]. A surprising result is that one respondent believes that there are no barriers in the implementation of GIS in high schools. Yet this same respondent must have also indicated that the large capital requirements needed for GIS is a barrier, since 100% of the respondents identified this as a barrier.

TABLE III. BARRIERS IN THE IMPLEMENTATION OF GIS

Barrier	Number of Participants (as Percentage)
The resources required are expensive	100
The training requirements for teachers are expensive or not accessible	42.1
Time required to prepare GIS-orientated lessons	26.3
Complexity of the Software	15.8
There are no barriers in the implementation of GIS	5.3
Other	5.3

From the data analysed and discussed above, a clear picture emerged not only on educators' understanding of GIS, but also their opinions of the SLP in GIS that was hosted by UJ, and on the implementation of GIS within high schools in South Africa. It would be a reasonable expectation that when the DBE of South Africa included GIS within the geography syllabus of the CAPS curriculum [1], that educators should be able to teach the new content and have a thorough understanding of this content. This is clearly not that case as teachers indicated they had no or very little knowledge of GIS before the SLP. Thus, the platform provided by the SLP in GIS by the University of Johannesburg is particularly important in terms of providing such training for geography educators and teachers within South Africa.

The problems respondents faced and identified were similar, if not identical, to those identified by educators in other countries [3], [6], [7]. However, this should not be a surprise due to the technical nature of GIS and the high financial capital required to implement GIS into high schools within a country. For countries, such as the USA, New Zealand and Japan, that are considered developed countries the amount of financial capital required for this implementation may be significantly less than for developing countries such as South Africa. This is particularly clear in this study where 100% of the respondents identified the cost of resources needed for the implementation of GIS as a major barrier. Secondly, 42.1% of the respondents identified training requirements for teachers are expensive or inaccessible, and this perhaps reflects a lack of support from educational boards or from appropriate governmental departments. This is further seen as educators who do seek to improve their level of knowledge in fields such as GIS are not able to do so as SLPs are expensive and/or inaccessible. A direct result of this is that educators do not have a complete understanding of the subject matter within the CAPS geography curriculum. This is clearly reflected in the end-of-year examination results. This is further alluded to the diagnostic reports of the final exams [10], [13].

Globally, all countries teaching GIS experience inequality within their schooling systems, as identified by other studies [3], [6]. As a result of such inequality, some educators have access to resources required to teach GIS and use GIS while some does not. This is regardless of whether educators have the skills and ability to teach and use GIS in the classroom as highlighted by references [5] and [7].

V. RECOMMENDATIONS

Through the fact that the importance of GIS within a secondary level education is clearly outlined by the Department of Basic Education of South Africa, the door is opened for the continuous assessment and study of the level of knowledge and skills of geography educators in South Africa. This study then acts as the foundation for further research to be done concerning the training of educators in GIS, at both a regional level and a national level. This study plays an important role in that it illustrates the importance of SLPs in GIS. This can be seen through the fact that this SLP helped in developing skills and knowledge in GIS, as well as developing skills that could be transferred and used within a classroom environment.

However, it is too soon to tell if such efforts have a large scale positive impact on the students of these educators. It is therefore recommended that a more in-depth study is conducted to determine if the knowledge and skills gained by attending a SLP in GIS is transferred in the teaching and learning process.

VI. CONCLUSION

The issue raised by the diagnostics reports [10], [13] that teachers are not familiar with GIS and lack fundamental knowledge, is one that can be solved. However, this will require intensive development of educators' skills and levels of knowledge towards the GIS section of the geography curriculum. Training programmes such as the one hosted by the University of Johannesburg will play a vital role in this development and training of geography educators. It is therefore crucial that funding for such SLPs are provided and that such SLPs are expanded to throughout South Africa.

It was found that the biggest barrier that teachers experience in teaching GIS is the lack of access to the materials and resources needed to teach the content effectively. With 26.3% of respondents calling for more support from government as they cannot teach the practical components of GIS due to this lack of resources. There is a clear shortfall in the knowledge of GIS, as

63.2% of the participants felt that they did not have a good understanding of GIS before attending the SLP. It is clear that the educators who attended the SLP did benefit from the course as 94.7% of the respondents are able to apply what they learnt into the classroom environment. There are several clear recommendations to improve the SLP. Such recommendations include the need for follow up workshops, the need for the SLP to address how to translate what they had learnt into the classroom environment and to include a section on remote sensing and its applications.

Even though the results of GIS component in the final examination is dismal, very little research is available to provide reasons and solutions to this. Therefore, more research is needed to achieve an understanding of the level of geography educators' training in GIS in a South Africa. This can provide valuable information and guide the training of teachers in GIS.

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