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Perspectives of GIS Education in High Schools: An Evaluation of uMgungundlovu District, KwaZulu-Natal, South Africa

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Abstract: Geographic Information Systems (GIS) education in South Africa and elsewhere has been envisioned to be a strategy that can contribute to new ways of teaching, learning and understanding. However, very few studies have assessed how GIS is taught in South African high schools. Consequently, this study aims to analyze GIS education dynamics and perspectives in uMgungundlovu District, KwaZulu-Natal Province, South Africa. A survey with both open and close-ended questions was conducted with geography educators and geography students. Questions focused on GIS content, how the content is taught, challenges in GIS education, educators' GIS proficiency and GIS education perspectives. The sample was guided by purposive sampling that intentionally selected schools with the desired qualities. From the results, it was evident that GIS is progressively taught in secondary schools. However, the full potential of GIS education has been restricted by challenges such as inadequate resources and limited exposure of students to GIS's practical uses. Subsequently, the study recommends that GIS education in South African schools should be accompanied by appropriate hardware, software and opportunities for exposing students and educators to practical methods of teaching and learning GIS. Furthermore, educators should also be trained to be able to adequately equip students with GIS skills and knowledge.

Keywords: GIS education; geography; high schools; students; educators; South Africa

1. Introduction

Geographic Information Systems (GIS) has been globally recognized as a multifaceted technology with a powerful visual dimension that carries great potential for enhancing and creating highly informed spatial decisions [1]. Despite being established for scientific land management purposes in Canada during the 1960s, the system has gradually filtered to other fields. However, Incekara [2] asserts that GIS has not been an important part of geography, consequently, its diffusion is slow in secondary schools. Likewise, the United Nations Committee of experts on Global Geospatial Information Management (UN-GGIM) also called for the integration of GIS into education. Thus, Kerski, [3,4] highlights how the Environmental Systems Research Institute (ESRI) is credited for the popularization of GIS from environmental management to education.

GIS can be regarded as the center of all modern spatial decision-making tools [5]. By common definition, GIS is as a computer system for capturing, storing, analyzing, managing and presenting data and associated attributes which are spatially referenced to Earth [6–8]. GIS integrates hardware, software, data, methods and people to enable preparation, interpretation and presentation of spatial data [6]. Through the application of geospatial tools, a prospective visual dimension of data is enabled by maps that facilitate discourse and communication between different stakeholders [5].

Education forms part of the Sustainable Development Goals and can be regarded as a critical constituent of improving a person's quality of life. As a basic human right, education is important for apprehending other human rights and creating opportunities for accessing broader social, economic, cultural and political benefits [9]. In relation to GIS and education, Goodchild and Kemp [10] were amongst the first scholars to argue for the use of GIS in schools because they strongly believed that obtaining GIS data was becoming more possible. Thus, students would be at an advantage of using technology with a local impact that can enhance their interest in geography while also offering prospects for future careers.

GIS and education interact in two ways, namely, learning through GIS and learning about GIS [1]. Learning through GIS relates to using GIS as an educational tool that offers additional means to develop important spatial abilities. Learning about GIS corresponds to the need for education programs that train people to become GIS practitioners [1]. Against this background, geography standards consist of GIS knowledge that can be classified into two levels, namely, GIS application and GIS awareness [11]. GIS application refers to making use of GIS for higher-order thinking, such as decision-making or problem-solving [11]. Complementary to this, GIS awareness refers to how standards clearly mention GIS but only introduce GIS concepts and functions [11].

According to [10,12], the introduction of GIS in secondary schools is supported by four substantive reasons: firstly, the fact that GIS is a progressively imperative technology in the workplace, especially in local government. Secondly, GIS is an important tool for decision-making and environmental analysis. Thirdly, GIS is a technique of motivating students' interest in geography, thus contributing to the improvement of geographic education. Lastly, GIS is an attractive application of technology that is capable of motivating students toward careers in science and engineering. GIS is therefore relevant given the current wave of the fourth industrial revolution.

In South Africa, geography performance has been unstable and declining since 2014 [13]. However, the subject remains one platform where GIS education can be advanced. This means geography content, including GIS, is not progressively improving students' spatial thinking capabilities despite geography being an appropriate subject to include GIS. In a majority of South African schools, GIS education is offered from grade 10 to 12 geography, as stipulated by the Department of Basic Education (DBE) [14,15]. The 2011 Curriculum and Assessment Policy Statements (CAPS) document further emphasizes that GIS skills should be included from the first term of grade 10–12 [14,15]. Nevertheless, there has been minimal research focusing on the review, impact and success of GIS in high schools in South Africa [16,17]. Most studies on GIS education in high schools have been carried out in America and Europe [5,18–23]. Consequently, the aim of the study is to analyze GIS education dynamics and perspectives in uMgungundlovu District, KwaZulu-Natal province, South Africa. The objectives are to (1) determine GIS content taught in high schools, (2) evaluate how the content is taught, (3) identify the proficiency of GIS educators and (4) glean the perspectives of GIS from both the students and educators. The remainder of the paper is structured as follows: the next sections looks at related works, followed by the materials and methods section; results and discussion are discussed next, and lastly, conclusions are presented.

2. Related Works

With regards to GIS content and teaching at the high school level, geospatial technologies can be integrated to assist students with comprehending various subjects that include geography, science, technology, engineering, mathematics and economics [1,24–27]. However, the most relevant subject is geography [11]. GIS should be included in the geography curriculum because of its role in enabling geographical research [28]. Therefore, GIS education, especially in geography, is helpful for exposing students and educators to the opportunity of participating in a teaching and learning approach that enhances cartographic skills [28,29], decision-making and problem-solving [14–17]. Due to its content benefits, GIS education has attracted the attention of various schools in different countries globally [29]. Musakwa [30] concurs by explaining that the use of GIS initially began in developed countries but is now increasingly filtering to developing countries. Developed countries such as the United States, the United Kingdom and Australia are amongst the few leaders of GIS education [19]. Denmark, China, Finland and Japan also form part of countries that are well-equipped to utilize GIS resources [20]. However, developing countries are lagging behind as they are in the early implementation stages of GIS education in high schools [6,20,21]. In other southern Africa countries, such as Mozambique and Zimbabwe, GIS education is not even implemented in high schools [23].

Compared to the United States, where GIS education was adopted in 1996 [31], and Chinese high schools, where GIS education is included in the curriculum standards for compulsory and elective courses [32], studies by [33,34] reveal that South African GIS education is still in its infancy stage [23]. Hence, GIS education continues to be a field that requires widespread attention and implementation. In South Africa, schools abide by the jurisdiction of the Department of Basic Education (DBE) [28]. Included in the South African curriculum of public and private schools are the Curriculum and Assessment Policy Statements (CAPS), Independent Examination Board (IEB) and the Cambridge curricula [29]. From 2006–2008 GIS was introduced in the grades 10–12 geography curriculum as part of the National Curriculum Statement (NCS). However, in 2013, the section was later revised in the Curriculum Assessment Policy Statements, but it is not widely spread in the classroom [29]. Amongst the aims of the geography subject is to promote the use of new technologies, such as ICT and GIS [28]. Solari and others [35] have noted that geography education is about meaningful learning starting from geographic questions. Thus, the GIS section should include content that cultivates spatial thinking and spatial decision-making, since GIS works best with geographically referenced data.

Teaching geography is integral for preparing students for key competences of lifelong learning as recommended by the European Union [36]. In geography, GIS has become a helpful technology for promoting learner understanding of the subject because it allows visual illustration and manipulation of central concepts of the discipline [34]. Multiple studies [33,34,37–39] have realized the great potential of GIS content in education, but Roulston [40] commends GIS education for supporting innovative teaching and learning by allowing students to explore information, analyze and report their results through maps. Fargher [41] reveals that GIS allows spatial relationship questions to be asked in ways that cannot be readily accessible outside of a GIS. Balram [42] also asserts that early efforts to increase the infusion of GIS into education resulted to the value of explicit spatial thinking [2]. Moreover, the study by [30] focused on questions that assess the impact of GIS on student knowledge, comprehension, application, analysis, synthesis and evaluation skills. These GIS perspectives results proved that the use of GIS spatial terms and software enhances spatial thinking and spatial cognitive skills better than traditional teaching methods, such as rulers and calculators. Thus, GIS education has developed to be accompanied by various spatial analysis, teaching and learning benefits. Despite these advantages, various challenges hinder effective and efficient GIS education implementation. Amongst these challenges are computer hardware and software constraints and limited exposure of educators to GIS application skills and knowledge, as well as inadequate educator development and pedagogical guidance [37,43–45]. In countries such as Tanzania, GIS education challenges are rooted in the country's limited resources for establishing appropriate infrastructure for acquiring E-learning courses and Web-based educational products [46].

Consequently, it is worth noting that the integration of GIS into teaching and learning will not be realized unless GIS education barriers are transformed into opportunities. Given the resource shortages that burden the South African education system, Interactive-GIS-Tutor (IGIST) [37] and GIS camps [29] can be adopted as strategies of enhancing GIS education and GIS proficiency for both students and educators.

Other strategies include geobrowsers [2], human capacity development [10,38], software support [20,27] and GIScience [15,39,40]. Piotrowska and Fargher [36,41] also suggest paper-based GIS, but [42] criticize this option, since GIS is a computer system that needs to be supported with appropriate computer hardware and software.

Teaching and learning GIS is accompanied by the development of geographic knowledge and geographic thinking skills. Thus, continuous educational research is required to sustain the momentum of GIS education. While GIS incorporates five components, Tan and Chen [39] reiterate that the prosperous introduction of GIS in education requires an integrated and multi-tiered response that ranges from educators, schools and the greater stakeholders of the public and private sector.

3. Materials and Methods

3.1. Study Area

uMgungundlovu District (Figure 1) is one of twelve education districts in KwaZulu-Natal Province, South Africa. According to the National Education Policy Act (Act no. 27 of 1996), education boundaries are demarcated differently from municipality boundaries, since the Member of the Executive Council (MEC) for Education has the power to demarcate, organize and name education districts and circuits in each province. With a total of 489 schools, uMgungundlovu District has 127 high schools, 50 independent (private) schools and 33 combined schools. A total of 117 schools teach geography, but the study focused on eight schools that use different teaching and learning curricula. In a majority of South African schools, GIS education is offered for grade 10–12 geography [40]. Hence, the study focused on grade 10–12 students and educators because the Curriculum and Assessment Policy Statement (CAPS) [40] emphasizes that the geography subject aims to guide students towards GIS skills, knowledge and attitudes from grade 10 to grade 12. We focused on both private and government schools that offer the Independent Examination Board (IEB) and CAPS curriculum, respectively. This was done to compare how GIS education is taught in private and government schools.

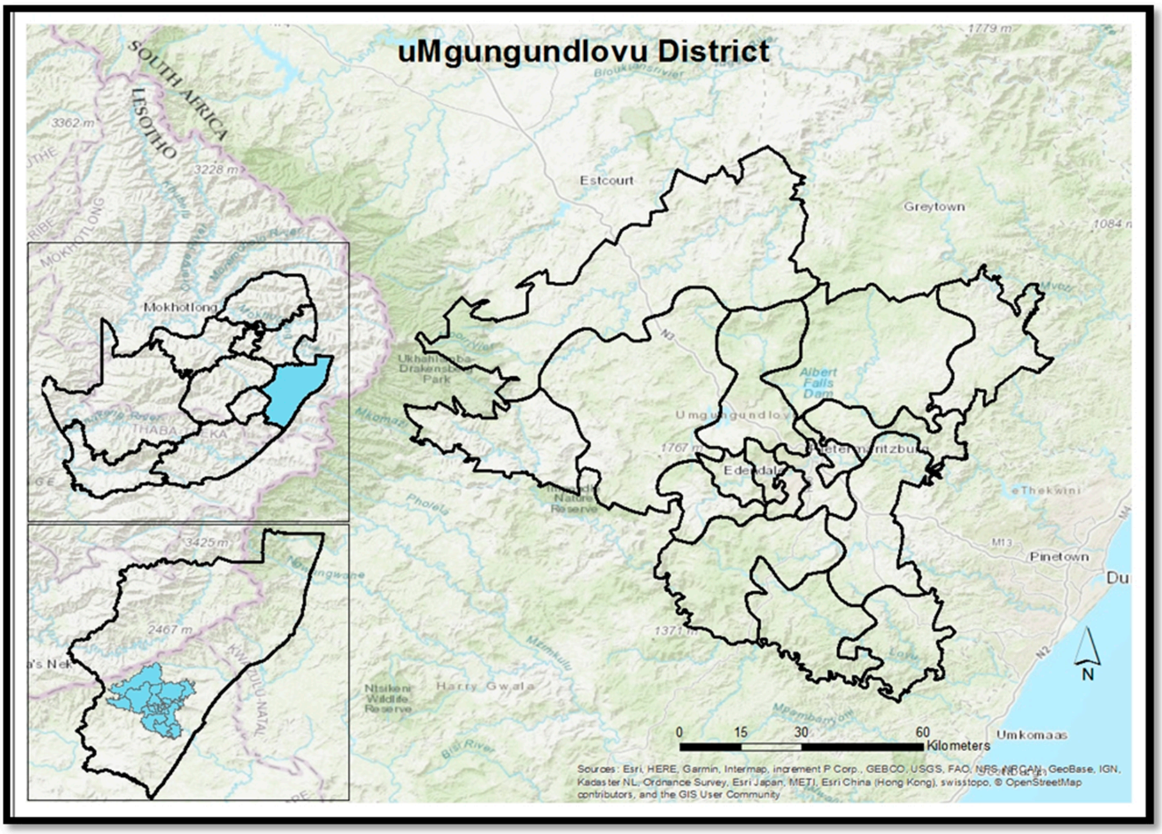

Figure 1. Study area (uMgungundlovu District, KwaZulu-Natal Province, South Africa).

3.2. Data Collection

A delimited case study approach where we focused on geography students and geography educators in schools within uMgungundlovu District, KwaZulu-Natal Province, South Africa was applied [47]. Delimited case study approaches have been applied successfully in educational research to capture aspects of GIS education and other educational concerns, such as teaching and learning, implementation of policy, curriculum development or issues of personal and professional relevance in various locations [46,47]. To collect data, we used two different questionnaires, one that was administered to geography students and another to geography educators. Before administering the questionnaires, ethical clearance was obtained from the Department of Basic Education and the University of Johannesburg ethics committee. We first piloted the questionnaires in May 2018 and adjustments were made before administering the final questionnaires in June 2018. The questionnaires were divided into demography and GIS perspectives sections. These questionnaires consisted of open-ended and close-ended questions that were guided by the four study objectives, which aimed to glean information on (1) GIS content taught in high schools, (2) how the content is taught, (3) proficiency of GIS educators and (4) perspectives of GIS from both the students and educators. Purposive sampling targeting geography educators and students was necessary to fulfill our objectives. A population of 60 geography students and 14 geography educators was selected. The sample was guided by selecting different school circuits (low income and high-income areas), ownership (private or public) and curriculum type (IEB or CAPS) so as to get a view of how GIS is taught in various situations (Table 1). Thirty students in both IEB and CAPS curriculum schools were selected for the study (Table 1) so as to maintain a balance between the curriculums. Eight educators in private schools and six educators in public schools were selected. Private schools in general had more geography educators compared to public schools. Students and educators were given the questionnaire in class to complete during the geography class and the researcher would explain and respond to questions if the students required help. The approximate time for completing the 22 questions on the educators' questionnaire was 30 min, while the 10 questions for students took approximately 20 min to complete. Forty-six female and fourteen male students as well as seven female and seven male educators participated in the study.

Table 1. Data collection sample.

Circuit	Ownership	School Curriculum	Students Interviewed	Educators Interviewed
Elandskop	Private	IEB	8	2
Pietermaritzburg Central	Private	IEB	8	2
Mpofana	Private	IEB	8	2
Inhlazuka	Private	IEB	6	2
Northdale	Private	CAPS	8	1
Edendale	Public	CAPS	8	1
Imbali	Public	CAPS	6	2
Pietermaritzburg Central	Public	CAPS	8	2

3.3. Data Analysis

MATLAB software from MathWorks Inc., Natick, Massachusetts, USA and Google Sheets software from Alphabet Inc, Mountain View, California, USA were used to analyze the data from the questionnaires. Descriptive statistics were applied to summarize the data according to different themes, namely (1) GIS content in high schools, (2) how the content is taught, (3) educators qualifications and (4) GIS perspectives from both the students and educators.

4. Results and Discussion

4.1. GIS Content

The combined demography results of educators and students indicated that there were more female respondents (63%) as compared to male respondents (37%). While 37% of educator respondents were 50 years old and above, a majority of student respondents (40%) were 17 years old. These results are encouraging, since older educators hold a wealth of teaching experience, which is accompanied by an understanding of the classroom environment. Despite the problems of some old educators lacking confidence, skills and knowledge of applying GIS and other ICT teaching methods in the classroom, these educators can still contribute to escalating effective GIS education.

Students were represented by 27% grade 10 students, 35% grade 11 students and 38% grade 12 students. Additionally, when the race of students and educators was combined, the African race population represented the majority of respondents (44%). This was followed by White (32%), Asian (22%) and other race groups (2%). Given these results, the sampled schools represented the South African ethnical diversity.

Regarding GIS content taught in high schools, Figure 2 below illustrates that there was a fair distribution of GIS content taught to grade 10 students. GIS concepts are the most taught content. Since grade 10 is an introductory phase, all content is supposed to be progressively and systematically taught to enhance geography understanding and performance. Consequently, these results call for effective intervention that can accelerate the implementation of other content.

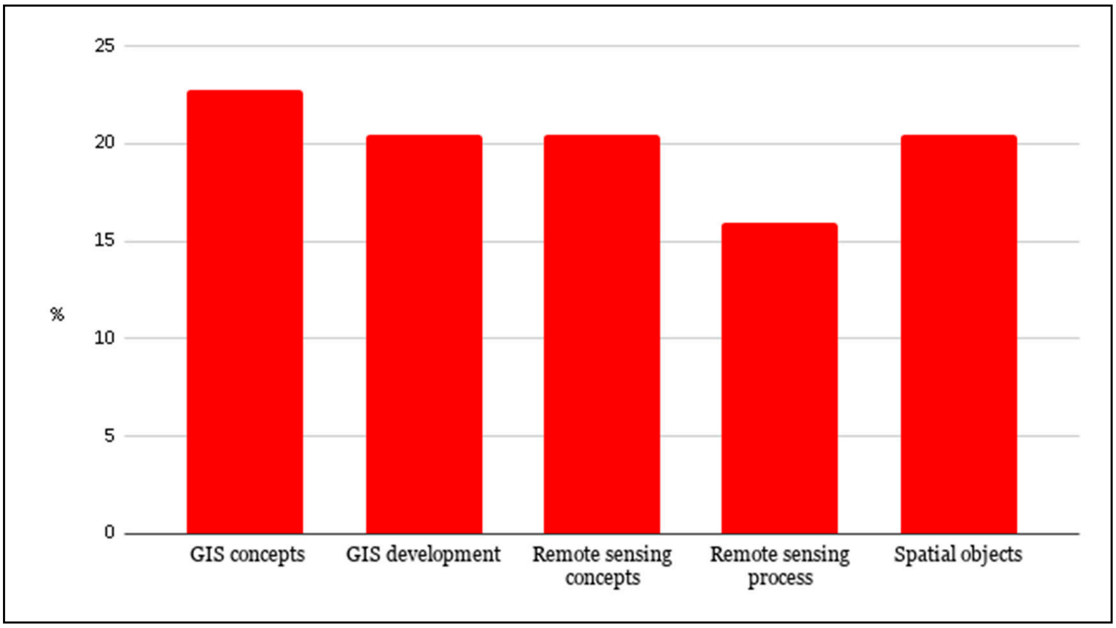

Figure 2. Grade 10 Geographic Information Systems (GIS) content in uMgungundlovu District schools, KwaZulu-Natal Province, South Africa.

Likewise, Figure 3 shows an even distribution of GIS content taught to grade 11 students. A majority of educators focus on teaching types of GIS data as well as raster and vector data. These results show balanced and progressive GIS education implementation. However, more efforts could be directed towards ensuring that every educator teaches all of the required content. This would ensure that students are adequately equipped with knowledge and skills for applying GIS to all relevant topics in grade 12.

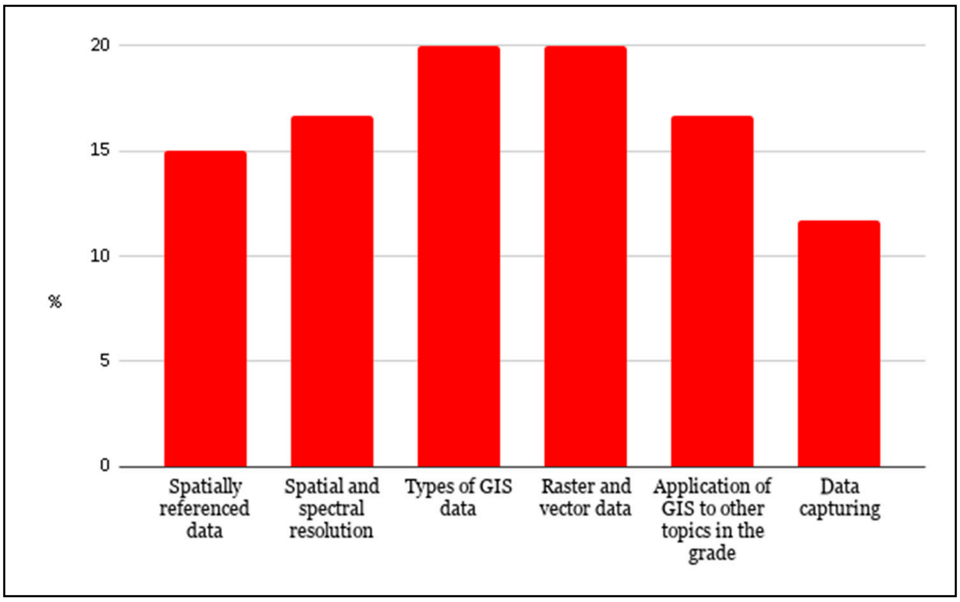

Figure 3. Grade 11 GIS content in uMgungundlovu District schools, KwaZulu-Natal Province, South Africa.

Figure 4 displays grade 12 content. These results revealed deplorable statistics, which highlight that GIS applications were the lowest taught content. This implies that most educators did not apply GIS knowledge and skills to other relevant content. This is a major concern, because students are not channeled towards acquiring geographic skills that will assist with enhanced spatial analysis. Subsequently, implications escalate to affect the overall geography pass rate of matric students. While data manipulation proved to be the most taught content, there remains a need to equip educators with teaching resources that will enhance the learning environment. As in Japan, where it is mandatory for senior high school educators to implement practical GIS applications [48], similar development strategies can be adopted in uMgungundlovu District and South African high schools.

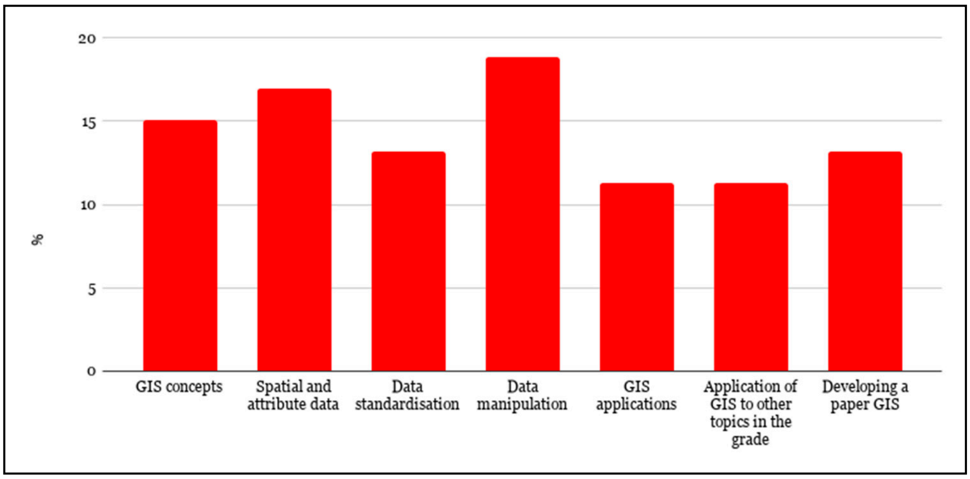

Figure 4. Grade 12 GIS content in uMgungundlovu District schools, KwaZulu-Natal Province, South Africa.

4.2. GIS Teaching Environment

This section evaluates how GIS content is taught, because the content of geography has undergone a series of changes that have been influenced by the revision and amendments of the South African education curriculum [49]. While private and public schools continue to show major discrepancies with regards to teaching GIS, the CAPS document prescribes all content that should be taught for each subject, including geography. Figure 5 highlights teaching time per geography period (Figure 5a) and GIS teaching duration per year (Figure 5b) in the district. Only 36% of geography periods were taught four or more times a week for 55 min or above (prescribed minimum standard in the CAPS document). Other periods were below the minimum standard because they were taught three times or below for less than 55 min a week. Despite CAPS explaining that geography should be taught for four hours per week in order to include consolidation, revision and assessment (formal and informal) time, this requirement has not been practiced by all schools. Subsequently, students' spatial thinking, problem-solving and critical thinking skills remain overlooked. Moreover, 62% of educators taught GIS for 1–2 weeks a year, 23% taught for 3–4 weeks and 15% taught for 5–6 weeks. This time proved to be insufficient because the 2011 DBE guidelines explain that GIS techniques and skills should be applied in every term of the Further Education and Training (FET) band (grade 10–12). The lack of adequate teaching time is another issue that hampers GIS education in high schools, as has been reported elsewhere [4,21,23]

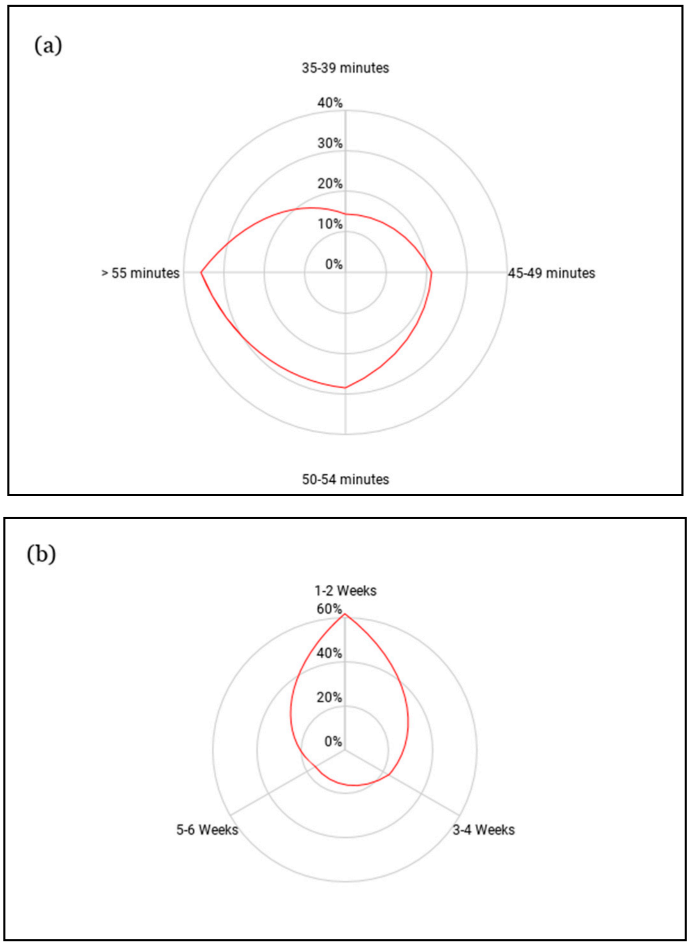

Figure 5. Teaching time (**a**) per geography period and (**b**) GIS teaching duration per year in uMgungundlovu District schools, KwaZulu-Natal Province, South Africa.

These results are a grim reminder of how GIS is not adequately integrated into specific sections of geography. Thus, the CAPS document ought to introduce flexible teaching guidelines that will allow GIS to be effectively applied to different sections throughout the year. In countries such as the United States, Canada and European countries, GIS is not confined to geography but is taught in other subjects as well [3,12]. This means that more time is spent on enhancing students' knowledge. This difference between South Africa and other countries asserts that DBE should at least aim to introduce teaching strategies that will allow GIS education to be transferred with optimum spatial analysis opportunities.

When comparing private and public schools within the study area, resource disparities were clear as all private schools had functioning computer laboratories while few public schools had computer laboratories. Results regarding teaching and learning with ICT revealed that the potential of GIS is yet to be realized, because only 27% of schools had computer labs while the other 73% remain in dire need. This digital divide is deeply rooted in the high number of South African schools without computer equipment. Statistics from [15] reveal that out of 24,793 South African public schools, only 2489 (10%) have computer equipment that supports computer labs. Without computers, advanced decision-making, creation of maps and analysis are impossible to teach. Even though 57% of educators teach theory and practical implementation, 43% teach theory only, because a few schools (24%) have teaching software such as QGIS or ArcGIS. Private schools are normally expensive, hence the majority of students cannot afford to be educated in them and opt for government schools [50].

Regarding learning ICT facilities, 62% of students did not have any ICT support facilities but 18% used smart boards and 7% used tutorial software, while 5% used digital resources and 8% used mobile resources such as cellphones (Figure 6). Despite the geography subject being touted as a means to promote the use of new technologies such as ICT and GIS [49], students are not adequately equipped with supporting resources. This unavailability of ICT for learning GIS does not only deprive students of learning advanced spatial analysis but also diminishes their motivation to learn geography.

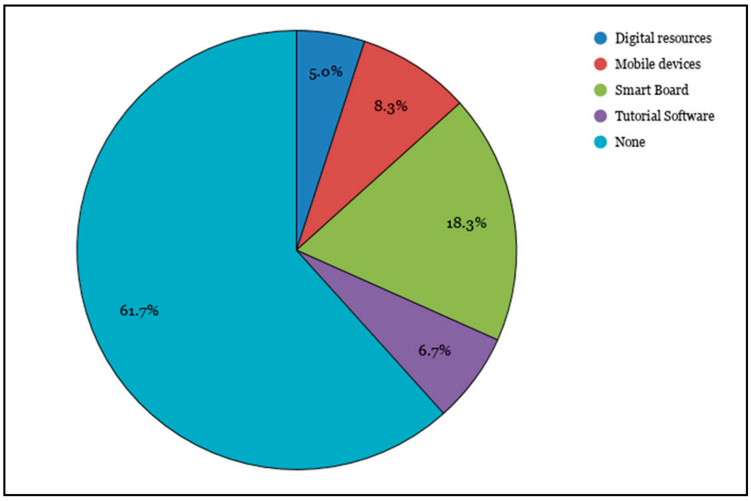

Figure 6. Learning Information and Communication Technology (ICT) facilities in uMgungundlovu District schools, KwaZulu-Natal Province, South Africa.

Similarly, Figure 7 below shows that 57% of educators did not have supporting ICT facilities for teaching GIS education. However, 14% used smart boards and tutorial software, while 7% used digital resources and mobile resources. Therefore, over half of educators teach in schools that are not equipped to support geobrowsers that enable educators and students to explore information, analyze and report their results through maps. Teaching with ICT has a great influence on motivating educators to teach with enthusiasm that can attract learners' interest in geography. Due to the beneficial prospects of ICT in GIS education, schools should be propelled towards ICT and using freely available software such as QGIS.

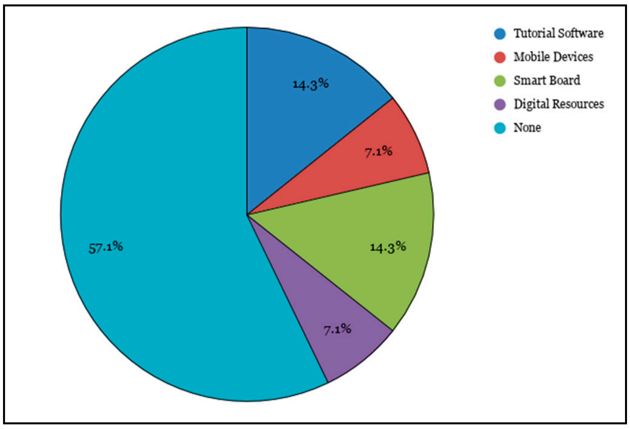

Figure 7. Teaching ICT facilities in uMgungundlovu District schools, KwaZulu-Natal Province, South Africa.

4.3. Educators' GIS Proficiency Levels

Concerning educators' GIS proficiency levels, findings shown in Figure 8 indicate that educators were mainly shaped through colleges and universities. Forty-three percent had a bachelor's in education degree (B.Ed.), 36% had a postgraduate certificate in education (PGCE), 14% had a diploma and 7% had other qualifications.

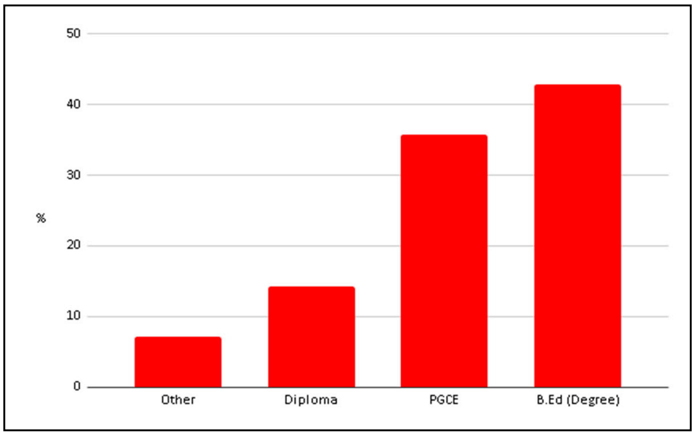

Figure 8. Educator qualifications in uMgungundlovu District schools, KwaZulu-Natal Province, South Africa.

Furthermore, 86% of the educators had modules such as GIS in their qualifications while 14% did not have GIS included in their qualifications. Given these results, there is a need for education stakeholders to continuously enhance educator skills with GIS support, resources and training. This is in stark contrast to China, where the problem of educators that teach without appropriate qualifications is avoided by ensuring that GIS forms part of the exam to become certified to teach geography [51]. Consequently, uMgungundlovu District and South Africa need to adopt stringent qualification measures. Hence, our study also confirms that educator qualifications are still an issue in South Africa and other countries such as the USA [3,23].

4.4. GIS Perspectives and Dynamics

GIS perspectives reflect on the opinions of students and educators with regards to the GIS teaching and learning environment. Figure 9 shows different constraints that impede the successful implementation and expansion of GIS education in schools, as identified by educators. These constraints were insufficient ICT support (28%), time constraints (28%), financial constraints for buying GIS hardware and software (23%), poor comprehension (13%) and lastly limited teaching (8%). As [52] asserts, there is a need for academic partnerships with GIS professionals and GIS software developers so that GIS education could be enhanced. Thus, it continuously remains essential for DBE to revolutionize the teaching and learning environment so that both students and educators could be globally competitive and equipped to manage and analyze large quantities of geographic data.

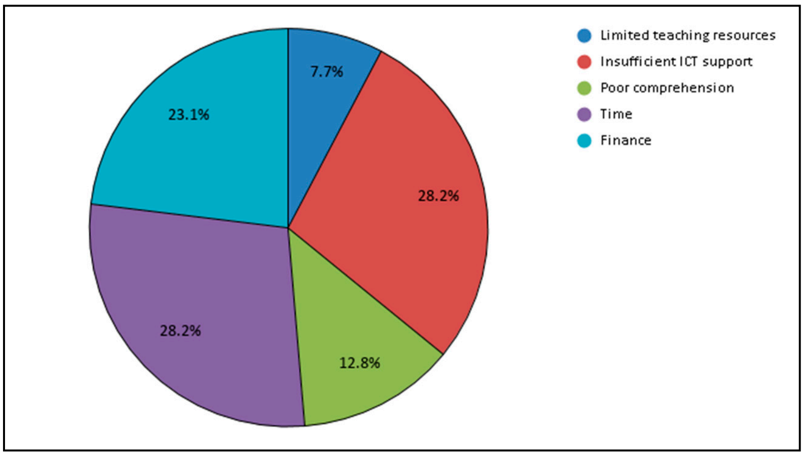

Figure 9. GIS education constraints.

Figure 10 shows the perspectives of how students comprehend GIS education content. Only 3% of students attested to having an excellent understanding of GIS, 30% had a good understanding, 53% had a fair understanding and 13% had a poor understanding. Students are still confronted by conceptual difficulties of comprehending geography content. As a result, Fleming [53] highlights how the CAPS document has been criticized for being overloaded and inflexible. Such criticism proves to be a burden that negatively affects the way educators teach, and subsequently how students understand GIS.

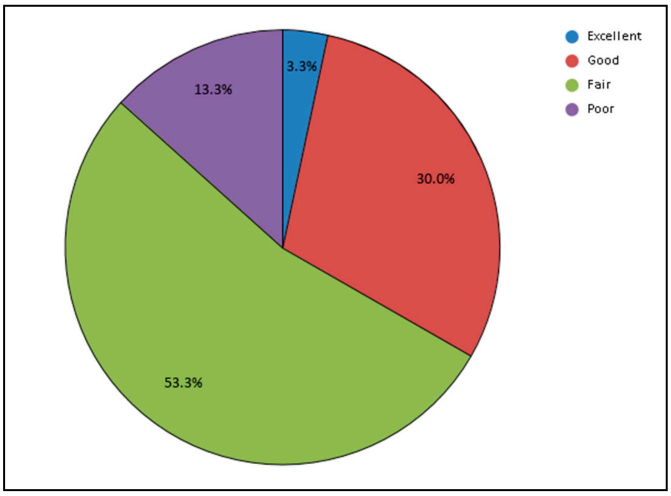

Figure 10. GIS comprehension.

Furthermore, the South African Department of basic Education, refs. [13,15] explain that since 2014, geography performance is still below the expected level. The results for 2014 and 2015 geography paper 2 (map skills) revealed that some GIS questions were frequently not answered by candidates [4]. Consequently, the 2014 results for the GIS section were 39%, representing the lowest results from the four questions of the paper [54]. In provinces such as KwaZulu-Natal, candidates failed to even attempt answering GIS questions. These realities emphasize how urgent and effective interventions are required to optimize GIS understanding for students.

Students further identified the data manipulation section as the most difficult when compared to spatial and spectral resolution, data capturing, spatially referenced data and GIS concepts (Figure 11). These results raise great concerns about prescribed GIS content and the way GIS is taught. This is because the grade 12 GIS content results revealed that the data manipulation section was the most taught section, but students still perceive it as the most difficult. Embedded in these comprehension ratings are complexities present within the teaching and learning environment of schools. Hence, new strategies are required to make GIS content more comprehensible to students.

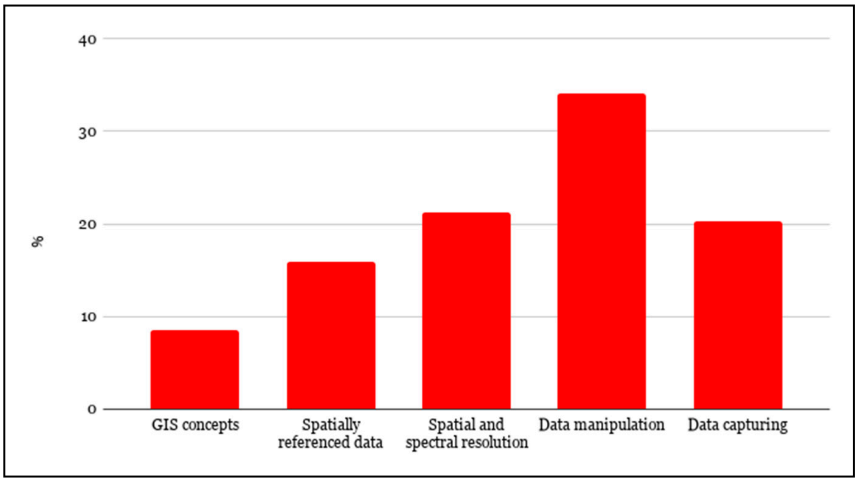

Figure 11. GIS difficulty as identified by students.

Nevertheless, GIS was regarded as a technology that enhances spatial thinking, because 70% of students agreed to GIS being a tool that cultivates critical thinking, spatial analysis and other spatial abilities. Only 30% did not agree to GIS being a tool that promotes spatial abilities. Similarly, Tan, Baker, Hong and the National Research Council [39,55–57] also allude to how GIS is a suitable information technology tool that promotes higher-order thinking skills such as decision-making and problem-solving.

In terms of GIS careers, only 33% of students would pursue a career in the GIS field. The other 67% of students would not consider a GIS career due to comprehension difficulties and disliking the field. Despite students not showing great interest in GIS or geography-related careers, 86% of educators would break all barriers in pursuit of achieving more GIS knowledge. These educators were interested in attending a GIS course, workshop or any GIS-related training. Jensen [51] asserts that professional upper-secondary educators in Denmark can individually and voluntarily apply for in-service training or refresher courses. In contrast to Denmark, uMgungundlovu District educators are still yearning for opportunities to attend GIS-related courses.

Analysis of GIS education perspectives highlighted that both students and educators need exposure to GIS's practical uses. These perspectives imply that GIS in education requires an integrated and multi-tiered response that ranges between educators, schools and the greater stakeholders of the public and private sector. Thus, support in the form of field trips, spending more time on teaching GIS content, human capacity development and GIS hardware (computers, tablets, smart boards and other digital infrastructure) is required for reviving interest in geography.

5. Summary and Conclusions

GIS education has increasingly secured a position in various schools worldwide. Although this education was pioneered by schools in the United States, Canada and European countries, South African schools have also adhered to the United Nations call of integrating GIS into education. This study focused on exploring the perspectives of GIS education in uMgungundlovu District. The results revealed that for objective (1) on GIS content, GIS concepts, raster and vector data and data manipulation are the most taught concepts in high schools in South Africa. Likewise, GIS content that is complex is progressively introduced between grades 10 to 12. Regarding objective (2) on how GIS content is taught, insufficient ICT support and inadequate teaching time are a reminder of how GIS is not adequately integrated into specific sections of geography. For objective (3) on geography educators' proficiency level, the majority of GIS educators had GIS qualifications, meaning that they are competent for teaching. For objective (4) on GIS perspectives, data manipulation was identified as the most difficult, and only a few students would consider GIS as a career. The study also showed that GIS education shows great promise as a channel for the diffusion of enhanced spatial thinking and improved geography performance. GIS education, especially in geography, has become so pervasive that it has been envisioned as a strategy that can contribute to new ways of teaching, learning and understanding spatial features. Nevertheless, there are challenges that include lack of finance and time constraints that still remain. Furthermore, the unstable geography pass rate is still a concern in South Africa. There are also big differences in teaching resources, where private schools are more endowed with digital and ICT facilities that enable them to teach GIS education better than government schools. Thus, the full potential of GIS education can only be unleashed when students and educators are exposed to using digital resources. Lastly, a limitation of our study is that we focused on a single case study; hence we recommend other studies on GIS education in high schools in South Africa and Africa in order to get an overall picture on GIS education in high schools.

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