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

中学GIS教育的前景南非夸祖鲁-纳塔尔省uMgungundlovu区评估

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| 摘要 | |
| 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. | 南非和其他地方的地理信息系统（GIS）教育已被设想为一种可以促进教学，学习和理解新方式的策略。但是，很少有研究评估南非中学如何教授GIS。因此，本研究旨在分析南非夸祖鲁-纳塔尔省uMgungundlovu区的GIS教育动态和观点。对地理教育者和地理学生进行了一个带有开放性和封闭性问题的调查。问题集中在GIS内容，如何教授内容，GIS教育中的挑战，教育者的GIS水平和GIS教育的角度。该样本以有目的抽样为指导，该抽样有意选择了具有所需质量的学校。从结果来看，很明显，中学正在逐步教授地理信息系统。但是，由于资源不足和学生对GIS的实际应用的接触有限等挑战，使得GIS教育的全部潜力受到了限制。随后，研究建议在南非学校进行GIS教育时，应配备适当的硬件，软件和机会，使学生和教育者了解GIS的实际教学方法。此外，还应该对教育工作者进行培训，使其能够为学生充分配备GIS技能和知识。 |

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| 介绍 | |
| 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. | 地理信息系统（GIS）已被全球公认为具有强大视觉范围的多方面技术，具有增强和创建高度知情的空间决策的巨大潜力[1]。 尽管在1960年代在加拿大出于科学土地管理目的而建立了该系统，但该系统已逐渐渗透到其他领域。 但是，Incekara [2]断言GIS并不是地理的重要组成部分，因此，它在中学中的传播速度很慢。 同样，联合国全球地理空间信息管理专家委员会（UN-GGIM）也呼吁将地理信息系统纳入教育。 因此，Kerski [3,4]强调了环境系统研究所（ESRI）如何因GIS从环境管理到教育的普及而受到赞誉。 |
| 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]. | 地理信息系统可以被视为所有现代空间决策工具的中心[5]。 按照通用定义，GIS是一个计算机系统，用于捕获，存储，分析，管理和呈现空间参考地球的数据和相关属性[6-8]。 GIS集成了硬件，软件，数据，方法和人员，可以进行空间数据的准备，解释和表示[6]。 通过应用地理空间工具，可以通过促进不同利益相关者之间的话语和交流的地图来实现数据的预期视觉维度[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. | 教育是可持续发展目标的一部分，可以被视为改善个人生活质量的重要组成部分。 作为一项基本人权，教育对于理解其他人权和创造获得更广泛的社会，经济，文化和政治利益的机会很重要[9]。 关于GIS和教育，Goodchild和Kemp [10]是最早争辩在学校中使用GIS的学者之一，因为他们坚信获取GIS数据变得越来越可能。 因此，学生将受益于使用具有本地影响力的技术，这可以增强他们对地理的兴趣，同时也为未来的职业提供前景。 |
| 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]. | GIS和教育以两种方式进行交互，即通过GIS学习和了解GIS [1]。 通过GIS学习与将GIS用作教育工具有关，该工具提供了开发重要空间能力的其他手段。 对GIS的了解与对培训人们成为GIS从业者的教育计划的需求相对应[1]。 在这种背景下，地理标准由GIS知识组成，可分为两个级别，即GIS应用程序和GIS意识[11]。 GIS应用是指将GIS用于更高阶的思维，例如决策或问题解决[11]。 对此的补充是，GIS意识是指标准如何清楚地提及GIS，但仅介绍GIS概念和功能[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. | 根据[10,12]，中学地理信息系统的引入有四个实质性原因：首先，地理信息系统是工作场所，尤其是地方政府中一种必不可少的技术。 其次，GIS是决策和环境分析的重要工具。 第三，GIS是一种激发学生对地理的兴趣的技术，从而有助于改善地理教育。 最后，地理信息系统是一种有吸引力的技术应用，能够激励学生从事科学和工程职业。 因此，鉴于第四次工业革命的浪潮，GIS具有重要意义。 |
| 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. | 自2014年以来，南非的地理表现一直不稳定且在下降[13]。但是，该主题仍然是可以推进GIS教育的平台。这意味着，尽管地理学是包括GIS的适当学科，但包括GIS在内的地理内容并未逐步提高学生的空间思维能力。根据基础教育部（DBE）的规定，在大多数南非学校中，提供10至12年级地理信息的GIS教育[14,15]。 2011年课程和评估政策声明（CAPS）文件进一步强调，应从10-12年级的第一学期起就包括GIS技能[14,15]。然而，在南非的高中，很少有研究集中在GIS的回顾，影响和成功上[16,17]。在高中，大多数有关GIS教育的研究都是在美国和欧洲进行的[5,18-23]。因此，本研究的目的是分析南非夸祖鲁-纳塔尔省uMgungundlovu区的GIS教育动态和观点。目标是（1）确定高中所教的GIS内容，（2）评估其内容的教,、（3）确定GIS教育者的熟练程度以及（4）从学生和教育者那里收集GIS的观点。本文的其余部分结构如下：下一部分介绍相关工作，其次是材料和方法部分。接下来讨论结果和讨论，最后给出结论。 |

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| 相关作品 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]. | 关于GIS内容和高中阶段的教学，可以集成地理空间技术来帮助学生理解包括地理，科学，技术，工程，数学和经济学在内的各个学科[1,24–27]。但是，最相关的主题是地理[11]。地理信息系统应被包括在地理课程中，因为它在促进地理研究中的作用[28]。因此，GIS教育，特别是地理教育，有助于使学生和教育者有机会参加可提高制图技能[28,29]，决策和解决问题[14-17]的教学方法。由于其内容优势，GIS教育已引起全球不同国家的各种学校的关注[29]。 Musakwa [30]同意解释说，GIS的使用最初是在发达国家开始的，但现在越来越多地被发展中国家使用。美国，英国和澳大利亚等发达国家是GIS教育的少数领导者之一[19]。丹麦，中国，芬兰和日本也构成了充分利用GIS资源的国家的一部分[20]。但是，发展中国家处于落后状态，因为它们处于高中GIS教育的早期实施阶段[6,20,21]。在其他南部非洲国家，如莫桑比克和津巴布韦，甚至在高中都没有实施GIS教育[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 | 与1996年采用GIS教育的美国[31]和义务教育和选修课程的课程标准中包括GIS教育的中国中学[32]相比，[33,34]的研究表明，南方非洲GIS教育仍处于起步阶段[23]。因此，GIS教育仍然是一个需要广泛关注和实施的领域。在南非，学校遵守基础教育部（DBE）的管辖权[28]。南非公立和私立学校课程包括课程和评估政策声明（CAPS），独立考试委员会（IEB）和剑桥课程[29]。从2006-2008年，GIS被作为国家课程大纲（NCS）的一部分引入了10-12年级地理课程。然而，2013年，该节后来在《课程评估政策声明》中进行了修订，但并未在课堂上广泛传播[29]。地理学科的目标之一是促进新技术的使用，例如ICT和GIS [28]。 Solari等人[35]指出，地理教育是关于从地理问题出发的有意义的学习。因此，由于GIS最适合地理参考数据，因此GIS部分应包含培养空间思维和空间决策的内容 |
| 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]. | 根据欧盟的建议，地理教学是让学生为终身学习的关键能力做准备的不可或缺的组成部分[36]。在地理学中，GIS已成为一种有助于提高学习者对学科理解的有用技术，因为它允许视觉插图和对学科核心概念的操纵[34]。多项研究[33,34,37–39]已经意识到GIS内容在教育中的巨大潜力，但Roulston [40]赞扬GIS教育通过允许学生探索信息，通过地图分析和报告结果来支持创新的教与学。 Fargher [41]揭示了GIS允许以GIS外部无法轻易访问的方式提出空间关系问题。 Balram [42]还断言，为增加GIS在教育中的投入所做的早期努力导致了明确的空间思维的价值[2]。此外，[30]的研究集中在评估GIS对学生知识，理解，应用，分析，综合和评估技能的影响的问题上。这些GIS观点的结果证明，与传统的教学方法（例如标尺和计算器）相比，使用GIS空间术语和软件可以更好地增强空间思维和空间认知技能。因此，GIS教育已发展为伴随着各种空间分析，教与学的益处。尽管有这些优点，但是各种挑战阻碍了有效，高效的GIS教育实施。这些挑战包括计算机硬件和软件的局限性，以及教育工作者对GIS应用技能和知识的了解有限，以及教育工作者的发展和教学指导不足[37,43-45]。在坦桑尼亚等国家，GIS教育的挑战根源在于该国资源有限，无法建立适当的基础设施来获取电子学习课程和基于Web的教育产品[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. | 因此，值得注意的是，除非将GIS教育的障碍转化为机会，否则将无法将GIS集成到教与学中。 鉴于资源短缺困扰着南非教育系统，可以采用交互式GIS导师（IGIST）[37]和GIS营地[29]作为增强学生和教育者的GIS教育和GIS能力的策略。 |
| Other strategiesinclude 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. | 其他策略包括地质浏览器[2]，人员能力开发[10,38]，软件支持[20,27]和GIScience [15,39,40]。 Piotrowska和Fargher [36,41]也提出了基于纸张的GIS，但是[42]批评了这种选择，因为GIS是一个计算机系统，需要适当的计算机硬件和软件来支持。 |
| 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 | GIS的教学和学习伴随着地理知识和地理思维技能的发展。 因此，需要持续的教育研究来维持GIS教育的势头。 尽管GIS包含五个组成部分，但Tan和Chen [39]重申，要将GIS引入教育中需要对教育者，学校以及公共和私营部门的更大利益相关者进行综合和多层次的响应。 |