WebGIS Implementation and Effectiveness in Secondary Education Using the Digital Atlas for Schools

使用学校数字地图集的WebGIS在中学教育中的实施和有效性

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| 摘要 | |
| The Digital Atlas for Schools is an innovative WebGIS development contributing to the use of geospatial information in schools. Based on a story map tool, it creates a geography curriculum constructed on ArcGIS Online. This article discusses the implications of implementing geospatial technologies so that learners can acquire spatial thinking and geographical knowledge, but also develop responsible and active spatial citizenship. Based on the learning progression approach, it presents results showing the effectiveness of this instructional resource, both for secondary school students and for geography teachers in training. The article concludes with a discussion on how results confirm the need for geospatial technologies to be better incorporated into the geography curriculum at secondary schools. | 学校数字地图集是一项创新的WebGIS开发，有助于在学校中使用地理空间信息。 它基于故事地图工具，可创建在ArcGIS Online上构建的地理课程。 本文讨论了实施地理空间技术的意义，以便学习者可以获取空间思维和地理知识，还可以发展负责任的积极的空间公民意识。 基于学习进度方法，它提供的结果表明了该教学资源对于中学生和地理老师的有效性。 本文最后讨论了结果如何确认需要将地理空间技术更好地纳入中学的地理课程。 |

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| 介绍 | |
| Besides teaching and learning methods, didactics, resources and curriculum, recent research in geographical education has focused particularly on key components of spatial thinking, geographical knowledge and, more recently, spatial citizenship. Current scientific literature argues that geospatial technologies, geographic information systems and other tools support and facilitate the acquisition of these three elements. This article illustrates the Digital Atlas for Schools, and examines its impact as an innovative and powerful tool for learning geography in school education, but also for geography teacher training. Based on the correlation between spatial thinking, geographical knowledge and spatial citizenship as a theoretical framework, this article evaluates the influence of WebGIS in geographical education. This influence is due to increasing implementation in geography classrooms and also previous empirical research that proves the effectiveness of geospatial technology for learning geography and acquiring spatial abilities. This article aims to obtain evidence for two main research questions: Do geospatial technologies foster better geography learning than conventional teaching, and, in particular, when using the Digital Atlas? Do geospatial technologies facilitate a balanced acquisition of spatial thinking ability, geographical knowledge, and spatial citizenship? | 除了教学方法，教学方法，资源和课程外，地理教育方面的最新研究尤其关注空间思维，地理知识以及最近的空间公民身份的关键组成部分。当前的科学文献认为，地理空间技术，地理信息系统和其他工具支持并促进了这三个要素的获取。本文介绍了“学校数字地图集”，并探讨了其作为一种创新且功能强大的工具在学校教育中学习地理学以及对地理教师培训的影响。本文以空间思维，地理知识和空间公民性之间的相关性为理论框架，评估了WebGIS在地理教育中的影响。这种影响是由于在地理教室中越来越多的实施以及以前的经验研究证明了地理空间技术对于学习地理和获取空间能力的有效性。本文旨在为两个主要的研究问题寻求证据 地理空间技术是否比传统教学能够促进更好的地理学习，特别是在使用数字地图集时？地理空间技术是否有助于平衡地获取空间思维能力，地理知识和空间公民身份？ |
| Going a step further, the purpose of this study is to examine the effectiveness of the Digital Atlas compared to conventional geography teaching and learning methods. A quasi-experimental design was used to evaluate the reliability of this new tool as a pedagogical resource to obtain improved instruction in several physical, human and regional geographical education topics. Findings and measurable results suggest a correlation between the use of the Digital Atlas and learning progressions. Does the Digital Atlas effectively contribute to better learning in geographical education and to what extent? Is the Digital Atlas equally valid for geography teacher training and for school education? These questions are explored in this article, which concludes with a discussion of implications and recommendations for the use of digital atlases in geographical education. | 更进一步，本研究的目的是检验数字地图集与传统地理教学方法相比的有效性。 准实验设计被用来评估这种新工具作为一种教学资源的可靠性，以便在一些物理，人类和区域地理教育主题中获得更好的指导。 调查结果和可衡量的结果表明，数字地图集的使用与学习进度之间存在相关性。 数字地图集是否有效地促进了地理教育的更好学习，并在多大程度上进行了？ 数字地图集是否对地理老师培训和学校教育同样有效？ 本文探讨了这些问题，最后讨论了在地理教育中使用数字地图集的含义和建议。 |

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| 背景 WebGIS 和 有效的地理学习 // Background: WebGIS and effective geography learning | |
| The rise in the use of several geospatial technologies in the classroom (virtual globes, remote sensing, GIS, WebGIS, GPS, geolocation mobile apps, and other geomedia and GeoICT resources) has transformed geography teaching practices in the past ten years. The use of active instructional practices, for example inquiry-based learning and problem-solving activities, has also increased in secondaryeducation classrooms, mainly in Europe and the United States (Bednarz and van der Schee 2006) but also in other parts of the world, including Asia and Latin America (Milson, Demirci, and Kerski 2012; Chen and Wang 2015; Demirci, De Miguel, and Bednarz 2018). | 在过去的十年中，教室中使用多种地理空间技术（虚拟地球仪，遥感，GIS，WebGIS，GPS，地理定位移动应用程序以及其他地理媒体和GeoICT资源）的兴起改变了地理教学方法。 在中等教育教室中，主要在欧洲和美国，活跃的教学实践（例如，基于探究的学习和解决问题的活动）的使用也有所增加（Bednarz和van der Schee，2006年），但在世界其他地区， 包括亚洲和拉丁美洲（Milson，Demirci和Kerski，2012； Chen和Wang，2015； Demirci，De Miguel和Bednarz，2018）。 |
| Although several challenges posed by the introduction of geospatial technologies in secondary school classrooms were debated around 20 years ago (ESRI 1998; Kerski 2003; Johansson 2006), the current widespread availability of geospatial data, spatial-data infrastructures, geomedia and WebGIS resources make their use indispensable for every “good and up-to-date geography lesson.” Further, capacity for valuable geography teaching for the future requires a comprehensive model for an updated geography curriculum (Jo and Muniz ~ 2015). Specifically, the International Geographical Union has acknowledged the importance of these tools through the recent International Charter on Geographical Education by stating that “geospatial technologies offer unique opportunities to make sense of the modern world” and form an invaluable 21st-century skill set for geographical education (Stoltman, Lidstone, and Kidman 2017). | 尽管大约在20年前就在中学教室中引入地理空间技术提出了若干挑战（ESRI 1998； Kerski 2003； Johansson 2006），但当前地理空间数据，空间数据基础设施，地理媒体和WebGIS资源的广泛可用性使得 在每个“最新的地理课”中都不可缺少。 此外，未来有价值的地理教学的能力需要用于更新的地理课程的综合模型（Jo and Muniz〜2015）。 具体而言，国际地理联盟通过最近的《国际地理教育宪章》确认了这些工具的重要性，并指出“地理空间技术为理解现代世界提供了独特的机会”，并形成了21世纪宝贵的地理教育技能 （Stoltman，Lidstone和Kidman 2017）。 |
| Some researchers go further and propose a change in the very nature and paradigm of geographical education, redefining it solely as digital geographical education (De Miguel, De Lazaro, and Marron 2012; Van der Schee et al. 2015) or even digital earth education (Kerski 2008; Fargher 2013; Donert 2014; Donert 2015). In addition to the many benefits of using geospatial technologies, digital geographical education unquestionably increases students’ motivation and interest in geography classes, as indicated by the previous literature. However, the main reason for using GIS in geography classrooms stems from two prominent pedagogical principles specific to our scientific discipline and school subject: spatial thinking and geographical knowledge. Uhlenwinkel (2013) underlines the differences between them, since the latter uses a subject-based approach. Nevertheless, other contributions (De Miguel 2016a; De Miguel 2016b) describe a parallel instructional sequence between spatial thinking and geographical knowledge to synthesize links within inquiry-based learning processes based on geospatial technologies. They also highlight the powerful role of geospatial technologies in addressing research challenges in geographical problems, geographical skills and geographical knowledge (De Miguel, Koutsopoulos, and Donert 2019). | 一些研究人员走得更远，提出了改变地理教育的本质和范式的建议，将其重新定义为数字地理教育（De Miguel，De L azaro和Marron 2012； Van der Schee等人2015）或什至是数字地理教育。地球教育（Kerski 2008; Fargher 2013; Donert 2014; Donert 2015）。正如先前文献所指出的那样，除了使用地理空间技术的许多好处之外，数字地理教育无疑会增加学生对地理课的动力和兴趣。但是，在地理教室中使用GIS的主要原因是针对我们的科学学科和学校学科的两个突出的教学原则 空间思维和地理知识。 Uhlenwinkel（2013）强调了它们之间的区别，因为后者使用基于主题的方法。然而，其他贡献（De Miguel 2016a； De Miguel 2016b）描述了空间思维与地理知识之间的平行教学序列，以基于地理空间技术综合基于查询的学习过程中的链接。他们还强调了地理空间技术在解决地理问题，地理技能和地理知识方面的研究挑战方面的强大作用（De Miguel，Koutsopoulos和Donert 2019）。 |

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| 空间思想 // Spatial thinking | |
| Spatial thinking has been well defined by the National Research Council’s Committee on Support for Thinking Spatially (2006) as a distinctive ability separate from general intelligence and as a constructive combination of cognitive skills (Metoyer and Bednarz 2017) based on a constructive amalgam of three elements: concepts of space, tools of representation, and processes of complex reasoning. Spatial visualization, spatial orientation and spatial relations are considered the three main spatial abilities of cognitive geography (Golledge and Stimson 1997; Lee and Bednarz 2009). In particular, spatial relations have been extensively outlined by several authors who establish differing taxonomies for spatial relations as a basic component of spatial thinking (Bednarz 2004; Gersmehl and Gersmehl 2007; Golledge, Marsh, and Battersby 2008; Janelle and Goodchild 2009; Jo and Bednarz 2009; Mohan and Mohan 2013; De Miguel 2016b). Recently, behavioral geography has introduced new approaches to study spatial thinking using cognitive neurosciences (Lobben and Lawrence 2015; Schinazi and Thrash, 2018). | 国家研究委员会的空间思考支持委员会（2006）已将空间思维定义为与一般智力不同的独特能力，并且是基于三个要素的建设性汞齐的认知技能的建设性组合（Metoyer和Bednarz 2017） 空间的概念，表示的工具以及复杂推理的过程。空间可视化，空间方向和空间关系被认为是认知地理学的三个主要空间能力（Golledge和Stimson，1997； Lee和Bednarz，2009）。特别是，几位作者对空间关系进行了广泛的概述，他们建立了不同的空间关系分类法，将其作为空间思维的基本组成部分（Bednarz 2004； Gersmehl和Gersmehl 2007； Golledge，Marsh和Battersby 2008； Janelle和Goodchild 2009； Jo和Bednarz 2009； Mohan和Mohan 2013； De Miguel 2016b）。最近，行为地理学引入了使用认知神经科学研究空间思维的新方法（Lobben和Lawrence，2015年; Schinazi和Thrash，2018年）。 |
| According to Metoyer and Bednarz (2017), spatial thinking is important for academic success in geography and other sciences, for example STEM domains (Wei, Lubinski, and Benbow 2005). Using geospatial technologies and GIS allows students to improve their spatial skills and spatial thinking, develop spatial abilities, solve spatial problems and increase their spatial reasoning. Geospatial technologies include geographical scales (local, regional, national and global), spatial analysis and research, but also explicit GIScience and tools (Roche 2014). Thus, national curricula and standards in the United States (Bednarz, Heffron, and Huynh 2013) and in European countries (Donert et al. 2016) recommend the use of geospatial technologies for daily activities in geography classrooms as essential for acquiring spatial thinking. | 根据Metoyer和Bednarz（2017）的研究，空间思维对于地理和其他科学领域的学术成功至关重要，例如STEM领域（Wei，Lubinski和Benbow 2005）。 利用地理空间技术和GIS，学生可以提高他们的空间技能和空间思维能力，发展空间能力，解决空间问题并增加其空间推理能力。 地理空间技术包括地理尺度（本地，区域，国家和全球），空间分析和研究，还包括明确的GIS科学和工具（Roche 2014）。 因此，美国（Bednarz，Heffron和Huynh，2013年）和欧洲国家（Donert等，2016年）的国家课程和标准建议，在地理教室的日常活动中使用地理空间技术对于获取空间思维至关重要。 |

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| 地理知识 // Geographical knowledge | |
| The difference between spatial thinking and geographical thinking involves considering the social, economic, political and cultural aspects of the human dimension (Hubbard et al. 2002) rather than merely topological aspects. In other words, geographical thinking involves applying spatial thinking to address complex geographic concepts or environmental and social problems (Metoyer and Bednarz 2017). Consequently, space, place and environment are key concepts for acquiring geographical thinking, complemented by other organizing concepts—such as scale, change, people, sustainability, interdependence, ecosystems, physical and human processes, landscape and cultural diversity, among others—included in most national geography curricula (De Miguel 2014a), particularly in England (Lambert and Morgan 2010). Geographical thinking taught using “traditional mental skills,” such as memorization, has now been replaced by problem-solving, reasoning and inquirybased approaches (Morgan 2018) in which geospatial technologies play an important role. | 空间思维和地理思维之间的差异涉及到考虑人类维度的社会，经济，政治和文化方面（Hubbard等，2002），而不仅仅是拓扑方面。换句话说，地理思维涉及运用空间思维来解决复杂的地理概念或环境和社会问题（Metoyer and Bednarz 2017）。因此，空间，地点和环境是获取地理思维的关键概念，并辅以其他组织概念，例如规模，变化，人，可持续性，相互依存，生态系统，自然和人为过程，景观和文化多样性等。大多数国家地理课程（De Miguel 2014a），特别是在英格兰（Lambert and Morgan 2010）。使用“传统心理技能”（例如记忆）教授的地理思维现已被解决问题，推理和基于询问的方法所取代（Morgan，2018年），其中地理空间技术起着重要作用。 |
| Inquiry-based learning was included in the National Geography Standards (1994) a decade after the publication of the Guidelines for Geographic Education (1984), which defined the five geographical skills for successful geographic inquiry-based learning: asking, acquiring, organizing, analyzing and answering geography questions. This scheme was adopted and adapted by papers describing the geo-inquiry approach in implementing geospatial technologies at school (ESRI 2003; Kerski 2011; Favier 2011; De Miguel 2013; Roberts 2013). | 在基于地理教育的指南（1984年）发布十年之后，基于查询的学习被纳入了《国家地理标准》（1994年），该指南定义了成功进行基于地理的查询学习的五个地理技能 询问，获取，组织，分析 并回答地理问题。 描述了在学校中实施地理空间技术的地理查询方法的论文采用了该方案并对其进行了修改（ESRI 2003； Kerski 2011； Favier 2011； De Miguel 2013； Roberts 2013）。 |
| However, not only are geospatial technologies powerful tools for developing spatial thinking, geographical thinking or inquiry-based learning, they also provide meaningful geographical subject matter for students, since they help them understand the world by contextualizing global and local geographical issues. An approach based on the GeoCapabilities international project confirms that it is possible to acquire powerful disciplinary knowledge with the use of geospatial technologies (Lambert, Solem, and Tani 2015; Butt 2017; Fargher 2018) | 但是，地理空间技术不仅是开发空间思维，地理思维或基于查询的学习的有力工具，而且还为学生提供了有意义的地理主题，因为它们通过将全球和本地地理问题具体化来帮助他们了解世界。 基于GeoCapabilities国际项目的方法证实，可以通过使用地理空间技术来获得强大的学科知识（Lambert，Solem和Tani 2015； Butt 2017； Fargher 2018） |

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| 空间公民 // Spatial citizenship | |
| Spatial citizenship provides a third essential component in geographical education along with spatial thinking and JOURNAL OF GEOGRAPHY 75 geographical knowledge. Consequently, geography educators need to raise awareness of the world’s spatial and social problems to turn learners into critical thinkers and citizens that propose actions to improve their everyday environment. The practical applications of geospatial technologies embedded in learning practices for traffic and transportation, smart-city approaches, environment, social media, and so on, contribute decisively to this instructional goal (Gryl, Jekel, and Donert 2010; Kim and Bednarz 2013; Bearman et al. 2016; Demirci, De Miguel, and Bednarz 2018; Donert, De Miguel and Lupi, 2019). | 空间公民身份与空间思维和《地理杂志》 75地理知识一起，在地理教育中提供了第三重要组成部分。 因此，地理教育者需要提高对世界空间和社会问题的认识，以使学习者成为批判性思想家和公民，他们提出了改善其日常环境的行动。 嵌入到交通和运输，智慧城市方法，环境，社交媒体等学习实践中的地理空间技术的实际应用，对这一教学目标起到了决定性的作用（Gryl，Jekel和Donert，2010年； Kim和Bednarz，2013年； Bearman 等人; 2016; Demirci，De Miguel和Bednarz 2018; Donert，De Miguel和Lupi，2019）。 |

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| 实作 // Implementation | |
| Geospatial technologies are not merely visual resources easing geography instruction. Their myriad benefits have transformed all dimensions of geographical education, from school curriculum to pedagogies, practices and styles of teaching and learning geography in primary and secondary education (Rod, Larsen, and Nilsen 2010; Del Campo et al. 2012; Heffron and Downs 2012; De Miguel 2014a; Chen and Wang 2015). Consequently, an approach focusing on textbooks runs parallel to the use of online resources. By boosting inquiry-based learning and problem-solving activities with geospatial technologies, students can enjoy a more dialogical, collaborative and integral learning experience. These technologies further their understanding of numeracy, graphics and map integration; they contribute data and resources for study cases; and they help perform meaningful fieldwork activities. They also improve individual learning and special-needs education, and provide a more accurate learning assessment. Furthermore, as geospatial technologies allow for SMART learning—self-directed, motivated, adaptive, resource-enriched, and technology-embedded—(Kim 2017), this new approach has been introduced into geography teacher education (pre- and in-service) as a factor for professional development (Fitzpatrick 2001; Hong 2015; Bryant and Favier 2015). Several selected contributions assessing geospatial-technology implementation in the classroom at international, national or individual levels conclude that comparing “analog” geographical education to digital geographical education no longer makes any sense (Bednarz and van der Schee 2006; Milson and Earle 2008; Lam, Lai, and Wong 2009; Bodzin 2011; Milson, Demirci, and Kerski 2012; Goldstein and Alibrandi 2013; Kerski, Demirci, and Milson 2013; Hwang 2013; De Miguel 2014b; Chen and Wang 2015; Collins 2018; Chang et al. 2018; Matusch et al. 2018; Kolvoord, Keranen, and Rittenhouse 2019). | 地理空间技术不仅是视觉资源，还可以简化地理教学。他们的无数好处改变了地理教育的方方面面，从学校课程到教学法，中小学教育地理学的实践和风格（Rod，Larsen和Nilsen，2010年； Del Campo等，2012年； Heffron和Downs，2012年） ； De Miguel 2014a； Chen and Wang 2015）。因此，侧重于教科书的方法与在线资源的使用并行。通过利用地理空间技术促进基于查询的学习和解决问题的活动，学生可以享受更加对话，协作和整合的学习体验。这些技术加深了他们对计算，图形和地图集成的理解；他们为研究案例提供数据和资源；他们有助于开展有意义的野外活动。它们还改善了个人学习和特殊需要的教育，并提供了更准确的学习评估。此外，由于地理空间技术支持SMART学习（自主，主动，自适应，资源丰富和技术嵌入）（Kim，2017年），因此这种新方法已被引入到地理教师教育中（职前和在职） （Fitzpatrick 2001; Hong 2015; Bryant and Favier 2015）。在国际，国家或个人级别上评估教室中地理空间技术实施情况的一些精选贡献得出的结论是，将“模拟”地理教育与数字地理教育进行比较不再有意义（Bednarz和van der Schee 2006； Milson和Earle 2008； Lam， Lai和Wong 2009; Bodzin 2011; Milson，Demirci和Kerski 2012; Goldstein和Alibrandi 2013; Kerski，Demirci和Milson 2013; Hwang 2013; De Miguel 2014b; Chen和Wang 2015; Collins 2018; Chang等人2018 ; Matusch等人2018; Kolvoord，Keranen和Rittenhouse 2019）。 |

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| 有效 Effectiveness | |
| Nevertheless, the effectiveness of geospatial technologies still proves rare in geospatial education research, which is particularly illuminating in a scientific field characterized by a paucity of empirical data and longitudinal studies. If empirical evidence based on tested and effective geography teaching models is required to shape decision-making in educational practice (Bednarz, Heffron, and Huynh 2013), then this is even more necessary for geospatial education research (Baker et al. 2015). For critical geospatial education research, one contribution (Kim and Bednarz 2013) obtains empirical evidence on links between spatial thinking and critical thinking, which we identify as spatial citizenship. Another study (De Miguel 2016a) also finds evidence of relationships between spatial thinking and geographical knowledge. Additional research, looking at the effectiveness of geospatial technologies in geography classrooms, provides evidence for the hypothesis that geospatial technologies foster stronger geography learning compared to conventional teaching (Audet and Paris 1997; Kerski 2003; Demirci 2008; Yap et al. 2008; Lee and Bednarz 2009; Lee and Bednarz 2012; Kerski, Demirci, and Milson 2013; Demirci 2015; Sharpe and Huynh 2015; Tan and Chen 2015; Hohnle et al. € 2016; Metoyer and Bednarz 2017; Sinha et al. 2017). This article adds to empirical research conducted with the Digital Atlas and WebGIS to provide some answers to the balanced acquisition of the three key components aforementioned: spatial thinking, geographical knowledge and spatial citizenship. | 但是，地理空间技术的有效性在地理空间教育研究中仍然很少见，这在以经验数据和纵向研究较少为特征的科学领域尤为明显。如果需要基于测试和有效的地理教学模型的经验证据来塑造教育实践中的决策（Bednarz，Heffron和Huynh，2013年），那么对于地理空间教育研究而言，这甚至是必要的（Baker等人，2015年）。对于批判性地理空间教育研究，一项贡献（Kim和Bednarz，2013年）获得了有关空间思维与批判性思维之间联系的经验证据，我们将其视为空间公民。另一项研究（De Miguel 2016a）也发现了空间思维与地理知识之间关系的证据。进一步的研究着眼于地理教室中地理空间技术的有效性，为以下假设提供了证据 与传统教学相比，地理空间技术可促进更强的地理学习（Audet和Paris 1997； Kerski 2003； Demirci 2008； Yap等人2008； Lee and Bednarz 2009; Lee和Bednarz 2012; Kerski，Demirci和Milson 2013; Demirci 2015; Sharpe和Huynh 2015; Tan和Chen 2015; Hohnle等人2016欧元; Metoyer和Bednarz 2017; Sinha等人2017）。本文将对使用Digital Atlas和WebGIS进行的实证研究进行补充，以为上述三个关键要素（空间思维，地理知识和空间公民权）的均衡获取提供一些答案。 |

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| WebGIS | |
| Of all available geospatial technologies, WebGIS is perhaps the most powerful, analytical and overall useful tool for geographical education, particularly in secondary education (Baker 2005; Johansson 2006; Baker 2015; Jo, Hong, and Verma 2016; De Lazaro, De Miguel, and Morales 2017; Fargher 2018; Kerski and Baker 2019). This in spite of difficulties involved in using and learning GIS (Rickles, Ellul, and Haklay 2017), successful initiatives illustrate instances in which secondary students use desktop GIS for highly sophisticated work (Kolvoord, Keranen, and Rittenhouse 2019). WebGIS has almost all the functionalities of a desktop GIS and is far easier for secondary school students to use, as proven by increasing use of it (Slocum et al. 2008; Hong 2014; Manson et al. 2014; De Lazaro, Izquierdo, and Gonzalez 2016). | 在所有可用的地理空间技术中，WebGIS也许是地理教育（尤其是中学教育）中功能最强大，分析能力最全面的有用工具（Baker 2005； Johansson 2006； Baker 2015； Jo，Hong和Verma 2016； De L azaro，De Miguel和Morales（2017）; Fargher（2018）; Kerski和Baker（2019）。 尽管在使用和学习GIS时遇到了困难（Rickles，Ellul和Haklay，2017年），但成功的举措表明了中学生使用桌面GIS进行高度复杂的工作的情况（Kolvoord，Keranen和Rittenhouse 2019）。 WebGIS几乎具有桌面GIS的所有功能，并且对中学生的使用要容易得多，这已得到越来越多的使用（Slocum等，2008； Hong 2014； Manson等，2014； De L azaro，Izquierdo） ，以及Gonz alez 2016）。 |
| WebGIS also has many advantages including accessibility, storage, ubiquity and speed advantages. It fosters a transdisciplinary approach to STEM education through integration and interoperability with other geospatial technologies, including mobile devices (GPS and geolocation data, open data, multi-scale data, real-time data and spatial-data infrastructures). It encourages the possibility of collaborative work combined through interface customization and personal learning. It allows for the deployment of inquiry-based learning and problem-solving activities focused on spatial analysis, the implementation of the TPACK (Technological Pedagogical Content Knowledge) instructional model (Hong and Stonier 2015); and the open dissemination of student mapping, including embedded in social media or storytelling, thus contributing to spatial citizenship and volunteered geographic information. | WebGIS还具有许多优势，包括可访问性，存储性，普遍性和速度优势。 通过与其他地理空间技术（包括移动设备（GPS和地理位置数据，开放数据，多尺度数据，实时数据和空间数据基础结构））的集成和互操作性，它促进了STEM教育的跨学科方法。 它鼓励通过界面定制和个人学习相结合的协作工作的可能性。 它允许部署基于查询的学习和解决问题的活动，重点是空间分析，TPACK（技术教学内容知识）教学模型的实施（Hong和Stonier，2015年）； 以及公开发布学生地图（包括嵌入社交媒体或讲故事），从而促进了空间公民身份和自愿提供的地理信息。 |

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| 用于学校教育的数字地图集 The Digital Atlas for school education | |
| This article is based on research conducted using a WebGIS application for geographical education: A Digital Atlas on 76 R. DE MIGUEL GONZÁLEZ AND M. L. DE LÁZARO TORRES ArcGIS Online, called the Digital Atlas for Schools (Atlas Digital Escolar, in the original version in Spanish; hereinafter, ADE). Atlases have always been a key instructional resource for teaching and learning geography in schools and beyond (Robert 1997). However, there are few relatively recent references to the design, use and assessment of digital atlases, virtual globes or interactive maps (Patterson 2007; DeMers and Vincent 2008; Bednarz and Bednarz 2015; De Miguel, Buzo, and De Lazaro 2016; De Miguel et al. 2016; Curtis 2019; Kerski and Baker 2019). | 本文基于使用WebGIS应用程序进行地理教育的研究 76 R. DE MIGUELGONZÁLEZ和ML DELÁZAROTORRES的数字地图集ArcGIS Online，称为学校数字地图集（Atlas Digital Escolar，西班牙语的原始版本） ；以下简称ADE）。 地图集一直是学校及其他地区地理教学的重要教学资源（Robert 1997）。 但是，很少有关于数字地图集，虚拟地球仪或交互式地图的设计，使用和评估的相对较新的文献（Patterson 2007； DeMers和Vincent 2008； Bednarz和Bednarz 2015； De Miguel，Buzo和De L azaro 2016； 2012）。 De Miguel等人，2016； Curtis，2019； Kerski和Baker，2019）。 |
| The team that created ADE comprised a mixed group of high-school and university geography teachers responsible for teacher-training programs, using ArcGIS desktop and, increasingly, ArcGIS Online, after its release in late 2012. They realized the power of this tool for creating maps collaboratively to facilitate the use of ArcGIS Online in geography courses for secondary education—both middle school and high school. The use of WebGIS software allows for a stronger pedagogical sequence in helping students to access and use geographic information. Thus, secondary school geography students can create their own maps, learn by doing, and simulate the tasks of a professional geographer through collaborative work on a project based on inquirybased learning, instead of memorizing geographical places. | 创建ADE的团队由负责教师培训计划的高中和大学地理老师组成的混合小组，使用ArcGIS桌面，并且在2012年底发布后，越来越多地使用ArcGIS Online，他们意识到了该工具的强大功能。 协作进行地图绘制，以方便在中学和中学的中学地理课程中使用ArcGIS Online。 WebGIS软件的使用在帮助学生访问和使用地理信息方面具有更强的教学顺序。 因此，中学地理学生可以在基于查询的学习的基础上通过在项目上的协作工作来创建自己的地图，边做边学，并模拟专业地理学家的任务，而不用记住地理位置。 |
| After several months of experimenting with map production, the group decided to organize a layout in several categories, in accordance with the main contents of the Spanish national geography curriculum, and to balance the number of maps for each category. They published maps in a story map/storytelling format to facilitate access to them in a user-friendly manner for secondary school students. | 经过数月的地图制作试验，小组决定根据西班牙国家地理课程的主要内容，组织几个类别的布局，并平衡每个类别的地图数量。 他们以故事地图/讲故事的形式发布地图，以方便中学生以用户友好的方式访问它们。 |
| ADE is organized in the format of a Web-mapping application with a very simple interface. The title page includes a YouTube video explaining ArcGIS Online for beginners, an explanatory text, followed by the category index. This design facilitates intuitive use by vertical scrolling, and offers possibilities to interact with ArcGIS Online or ArcGIS Desktop to continue creating and updating the maps. In addition, information obtained from statistical or cartographic sources (Excel tables or layer metadata in WMS, etc.) can be consulted in a specific pop-up window, as a Web-map format. If students have an ArcGIS account, they can update the data, modify the visual representation (colors, shapes, ranks, etc.) or add a new layer with complementary geographic information to provide more details on the geographical place or the geographical process. Open data published by public institutions, such as the Spanish National Geographic Institute (known by its Spanish abbreviation, IGN in Spanish) and the National Institute of Statistics (known by its Spanish abbreviation, INE in Spanish) were used to create ADE. Data from several international organizations, such as EUROSTAT, the United Nations, World Bank or the International Monetary Fund, and many others, allowed us to obtain official data and address Europe’s and the World’s geographical problems. | ADE以Web映射应用程序的格式组织，具有非常简单的界面。标题页包括一个YouTube视频，向初学者解释ArcGIS Online，一个解释性文本，以及类别索引。这种设计有助于通过垂直滚动进行直观的使用，并提供了与ArcGIS Online或ArcGIS Desktop进行交互以继续创建和更新地图的可能性。另外，从统计或制图来源（WMS中的Excel表格或图层元数据等）获得的信息可以在特定的弹出窗口中以Web地图格式进行查询。如果学生拥有ArcGIS帐户，则他们可以更新数据，修改视觉表示（颜色，形状，等级等）或添加带有补充地理信息的新层，以提供有关地理位置或地理过程的更多详细信息。使用公共机构（例如西班牙国家地理学院（以其西班牙文缩写，称为IGN）和国家统计局（以其西班牙文，INE称为INE））发布的公开数据来创建ADE。来自多个国际组织的数据，例如EUROSTAT，联合国，世界银行或国际货币基金组织（IMF）等，使我们获得了官方数据并解决了欧洲和世界的地理问题。 |
| The “Introductory Section” in the Digital Atlas provides different tools for using categories and learning geography:  1. The map itself, which covers the main screen area.  2. A pop-up window called “details” explains the map’s most important characteristics for a particular geographical issue. It also provides two links: an ArcLesson supplementing each map with a key instructional resource (spatial problem to be solved, questionnaire based on the map itself) and a link to the map (Web Map) for teachers or students registered with an ArcGIS account to access the map so they can add, remove or update data layers, etc.  3. A toolbar in the upper left area; the most important element as it allows the user control over the map’s interactivity, leading to potential acquisition of spatialthinking abilities through the map legend, layering, base-map gallery, measuring (linear, surfaces), geolocation coordinates (decimal degrees or degree, minutes and seconds), sharing the map, and bookmarks.  4. Other tools for searching places, zooming and changing scale. | 数字地图集的“入门部分”提供了使用类别和学习地理的不同工具：  1.地图本身，它覆盖主屏幕区域。  2.名为“详细信息”的弹出窗口说明了地图在特定地理区域中最重要的特征。 它还提供了两个链接：ArcLesson用重要的教学资源（要解决的空间问题，基于地图本身的问卷调查）补充每张地图，以及为已注册ArcGIS帐户的教师或学生提供的地图（Web地图）链接。 访问地图，以便他们可以添加，删除或更新数据层等。  3.左上方的工具栏； 最重要的元素，因为它允许用户控制地图的交互性，从而可能通过地图图例，分层，基础地图库，测量（线性，曲面），地理位置坐标（小数度或度，分钟）来获取空间思维能力 和秒），共享地图和书签。  4.其他用于搜索位置，缩放和更改比例的工具。 |
| Each map has two versions (an app version that is closed for changes and an open Web map version) supplemented by the ArcLesson. Consequently, there are three approaches to a specific topic, allowing students a broad set of possibilities for learning geography through diverse spatial pedagogies. | 每个地图都有两个版本（为更改而关闭的应用程序版本和打开的Web地图版本），并以ArcLesson为补充。 因此，针对特定主题有三种方法，使学生可以通过多种空间教学法来学习地理。 |
| After the title page and introduction, ADE is structured into four categories based on the main topics forming the national geography curriculum for middle school and high school in Spain. The reason for reproducing the curriculum structure in the Digital Atlas structure is to maintain the coherence in the geographical content of the national curriculum (physical geography and environment, population and settlements, human geography and economy, spatial imbalances and regional planning) and to simplify the interface for student interactivity with the maps. There is a fifth category in the ADE called “Experiences”, showing the best maps and student outcomes based on project-based learning. The entire ADE consists of these five categories, each containing several maps; for example, the first category—physical geography and environment—includes maps of relief, climate, vegetation, hydrology, landscapes, etc. Around 131 maps and 478 layers of geographic information are available for consultation, as modifiable instructional resources and as a map and databases for geography inquiry-based learning. The fact that the ADE was published in Spanish (and many layers are uploaded in English) helped disseminate the Digital Atlas widely, not only in Spain but also in Europe and Latin America: the Digital Atlas had over 80,000 visits from late 2015 (released) to 2019. | 在标题页和介绍之后，根据主要主题将ADE分为四个类别，这些主题构成了西班牙中学和高中的国家地理课程。之所以要复制“数字地图集”结构中的课程结构，是为了保持国家课程的地理内容（自然地理和环境，人口和居住区，人文地理和经济，空间失衡和区域规划）的连贯性，并简化学生与地图互动的界面。 ADE中有第五种类别，称为“体验”，显示了基于项目学习的最佳地图和学生成果。整个ADE包含这五个类别，每个类别包含多个地图。例如，第一类-自然地理和环境-包括地形图，气候，植被，水文学，风景等。大约131幅地图和478层地理信息可供查阅，可以作为可修改的教学资源，地图和基于地理查询的学习的数据库。 ADE以西班牙语发布（并且许多层以英语上传）这一事实不仅在西班牙而且在欧洲和拉丁美洲也广泛传播了数字地图集：从2015年末开始，数字地图集的访问量已超过80,000（已发布）至2019年。 |

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| 实施数字地图集进行地理教育研究 Implementing the digital atlas to conduct geography-education research | |
| 研究设计 Research design | |
| After disseminating the Digital Atlas, geography teachers in both secondary schools and teacher-training colleges began to make large-scale use of the tool. However, the authors, as geographical education researchers, wanted to implement JOURNAL OF GEOGRAPHY 77 the tool following a conventional research plan. First, a series of general objectives for the use of the Digital Atlas were defined: facilitating the acquisition of geographical knowledge following the national curriculum guidelines; encouraging critical geospatial thinking; fostering spatial analysis and spatial multicriteria assessment; taking advantage of open data; promoting learning standards and evaluation criteria; implementing civic education and lifelong learning— such as sustainable development; and, obtaining results based on evidence practices of the effectiveness of using geospatial technologies. However, besides these general objectives for any user, the research is based on the four aforementioned more specific and concrete key questions: How much better is the Digital Atlas than conventional geography learning? Can the Digital Atlas effectively contribute to learning progressions in geographical education and to what extent? Are geoinformation and the Digital Atlas equally valid for school education and for geography teacher training? Is the Digital Atlas useful for learning any kind of geography curriculum content and to what extent? Last, but not least, as mentioned previously, the research addressed the measurement of the real impact of geospatial technologies to promote better geography learning, and, moreover, some activities explored how the Digital Atlas contributes to the balanced acquisition of spatial thinking, geographical knowledge and spatial citizenship. The purpose of this study was to research future teachers’ and students’ awareness of geospatial technologies and obtain data on geographical knowledge learning outcomes (Tables 1–5). The results could potentially help the education community better understand how WebGIS (and, in particular, Digital Atlas) contribute to a deeper and more meaningful learning of geographical content, both in school education and in teacher training. This study followed the learning-progressionknowledge model that used a two-phased quantitative method described below | 在发布了数字地图集之后，中学和师范学院的地理老师开始大量使用该工具。但是，作为地理教育研究者，作者希望按照常规研究计划实施《地理杂志》 77。首先，定义了一系列使用数字地图集的一般目标：促进遵循国家课程指南的地理知识的获取；鼓励批判性的地理空间思维；促进空间分析和空间多标准评估；利用开放数据；促进学习标准和评估标准；实施公民教育和终身学习，例如可持续发展；并基于使用地理空间技术的有效性的证据实践获得结果。但是，除了针对所有用户的这些总体目标之外，该研究还基于上述四个更具体和具体的关键问题：数字地图集比传统地理学习的效果好多少？数字地图集能否有效地促进地理教育的学习进展，并在何种程度上发挥作用？地理信息和数字地图集对学校教育和地理教师培训是否同样有效？数字地图集对学习任何种类的地理课程内容有用吗？最后但并非最不重要的一点是，如前所述，该研究解决了对地理空间技术对促进更好的地理学习的实际影响的度量，此外，一些活动还探索了数字地图集如何为平衡获取空间思维，地理知识做出贡献和空间公民身份。这项研究的目的是研究未来的教师和学生对地理空间技术的认识，并获取有关地理知识学习成果的数据（表1-5）。结果可能会帮助教育界更好地了解WebGIS（尤其是数字地图集）如何在学校教育和教师培训中促进更深入，更有意义的地理内容学习。这项研究遵循了学习进步知识模型，该模型使用了以下所述的两阶段定量方法 |
| Table 1. Learning progressions for the climate topic with the Digital Atlas.  Level 0 No evidence of understanding  Level 1 Students understand climate concepts  Level 2 Students can identify climate regions  Level 3 Students understand how different geographical factors determine the climate  Level 4 Students can identify which geographic factors are more or less important for climate definition  Level 5 Students understand that some world regions are more affected by climate change | 表1.使用数字地图集学习气候主题的过程。  级别0没有理解的证据  1级学生了解气候概念  2级学生可以识别气候区域  3级学生了解不同的地理因素如何决定气候  4级学生可以确定哪些地理因素或多或少对气候定义至关重要  5级学生了解一些世界地区受气候变化影响更大 |
| Table 2. Learning progressions for the urban geography topic with the Digital Atlas.  Level 0 No evidence of understanding  Level 1 Students understand urban concepts  Level 2 Students can identify capital metropolitan regions in the world  Level 3 Students understand urbanization levels in different countries  Level 4 Students can identify urban regions based on urbanization level  Level 5 Students understand that urban population and urban network complexity is explained by economic wealth | 表2.使用数字地图集了解城市地理主题的学习进度。  级别0没有理解的证据  1级学生了解城市概念  2级学生可以识别世界上的首都地区  3级学生了解不同国家/地区的城市化水平  4级学生可以根据城市化水平确定城市区域  5级学生了解，城市人口和城市网络的复杂性是由经济财富所解释的 |
| Table 3. Learning progressions for the economy topic with the Digital Atlas.  Level 0 No evidence of understanding  Level 1 Students understand the globalization concept  Level 2 Students can identify regions with a higher export rate  Level 3 Students understand top ranked accessibility in the world’s more developed regions  Level 4 Students can identify relationships between accessibility and transportation density  Level 5 Students understand the spatial complexity of the globalization concept as international exchanges of goods and services, but also capitals and information, thus reinforcing spatial dependences and hierarchies | 表3.数字地图集针对经济主题的学习进度。  级别0没有理解的证据  1级学生了解全球化概念  2级学生可以确定出口率较高的地区  3级学生了解世界上较发达地区的顶级可访问性  4级学生可以确定可达性与交通密度之间的关系  5级学生将全球化概念的空间复杂性理解为商品和服务的国际交换，也包括资本和信息的国际交换，因此加强了空间依赖性和层次结构 |
| Table 4. Learning progressions for the spatial imbalances topic with the Digital Atlas.  Level 0 No evidence of understanding  Level 1 Students understand the population growth concept  Level 2 Students can identify regions with higher population growth  Level 3 Students understand relative economic growth (below average, above average)  Level 4 Students can identify regions based on economic growth, distinguishing which are more and less dynamic  Level 5 Students understand that there are spatial relationships explaining the link between demographic and economic growth | 表4.数字地图集针对空间不平衡主题的学习进度。  级别0没有理解的证据  1级学生了解人口增长概念  2级学生可以确定人口增长较高的区域  3级学生了解相对经济增长（低于平均水平，高于平均水平）  4级学生可以根据经济增长来确定地区，并区分哪些地区动态变化越来越小  5级学生了解存在一定的空间关系，可以解释人口与经济增长之间的联系 |
| Table 5. Learning progressions for spatial thinking with the Digital Atlas.  Level 0 No evidence of understanding  Level 1 Students can understand primitive geospatial concepts such as identity location  Level 2 Students can identify spatial distributions as a simple concept  Level 3 Students can establish geospatial relations and identify clusters in the map, a difficult concept  Level 4 Students can identify corridors and buffers in the map as complicated geospatial concepts  Level 5 Students acquire extended abstract thinking, as they can generalize complex spatial structures such as hierarchy or central place | 表4.数字地图集针对空间不平衡主题的学习进度。  级别0没有理解的证据  1级学生了解人口增长概念  2级学生可以确定人口增长较高的区域  3级学生了解相对经济增长（低于平均水平，高于平均水平）  4级学生可以根据经济增长来确定地区，并区分哪些地区动态变化越来越小  5级学生了解存在一定的空间关系，可以解释人口与经济增长之间的联系 |
| 学习进度模型 // Learning progression model | |
| One of the main concerns surrounding GIS implementation and effectiveness in schools involves monitoring the real impact of geospatial technologies on learning. In other words, do students learn more with or without digital mapping? And what is the extent of that learning? At the beginning of the Digital Atlas design, the enthusiasm for such a visually attractive and user-friendly tool as ArcGIS Online was palpable. Many educators at several geographyeducation conferences relayed the motivational factor of the Web-mapping interface for students. However, this geographical learning must be compared empirically to assess validity in accordance with curriculum standards. Therefore, reliable models and instruments were needed to confirm the hypothesis that students learn more successfully with ADE than with conventional approaches. The authors chose learning progression model, a well-regarded theoretical framework for learning outcomes in geographical education, to conduct research on Digital Atlas implementation. Learning progression has been the research model used for flagship initiatives by several institutions, such as the Commission on Geographical Education of the International Geographical Union (Muniz, Solem, and Boehm ~ 2016; Solem et al. 2018), the American Association of Geographers and the National Council for Geographic Education (Bednarz, Heffron, and Huynh 2013; Solem, Huynh, and Boehm 2014; Huynh, Solem, and Bednarz 2015; Larsen and Table 1. Learning progressions for the climate topic with the Digital Atlas. Level 0 No evidence of understanding Level 1 Students understand climate concepts Level 2 Students can identify climate regions Level 3 Students understand how different geographical factors determine the climate Level 4 Students can identify which geographic factors are more or less important for climate definition Level 5 Students understand that some world regions are more affected by climate change Table 2. Learning progressions for the urban geography topic with the Digital Atlas. Level 0 No evidence of understanding Level 1 Students understand urban concepts Level 2 Students can identify capital metropolitan regions in the world Level 3 Students understand urbanization levels in different countries Level 4 Students can identify urban regions based on urbanization level Level 5 Students understand that urban population and urban network complexity is explained by economic wealth Table 3. Learning progressions for the economy topic with the Digital Atlas. Level 0 No evidence of understanding Level 1 Students understand the globalization concept Level 2 Students can identify regions with a higher export rate Level 3 Students understand top ranked accessibility in the world’s more developed regions Level 4 Students can identify relationships between accessibility and transportation density Level 5 Students understand the spatial complexity of the globalization concept as international exchanges of goods and services, but also capitals and information, thus reinforcing spatial dependences and hierarchies Table 4. Learning progressions for the spatial imbalances topic with the Digital Atlas. Level 0 No evidence of understanding Level 1 Students understand the population growth concept Level 2 Students can identify regions with higher population growth Level 3 Students understand relative economic growth (below average, above average) Level 4 Students can identify regions based on economic growth, distinguishing which are more and less dynamic Level 5 Students understand that there are spatial relationships explaining the link between demographic and economic growth Table 5. Learning progressions for spatial thinking with the Digital Atlas. Level 0 No evidence of understanding Level 1 Students can understand primitive geospatial concepts such as identity location Level 2 Students can identify spatial distributions as a simple concept Level 3 Students can establish geospatial relations and identify clusters in the map, a difficult concept Level 4 Students can identify corridors and buffers in the map as complicated geospatial concepts Level 5 Students acquire extended abstract thinking, as they can generalize complex spatial structures such as hierarchy or central place 78 R. DE MIGUEL GONZÁLEZ AND M. L. DE LÁZARO TORRES Harrington 2018), the European Association of Geographers, EUROGEO (Zwartjes 2014; Donert et al. 2016) but also by researchers in the UK (Weeden 2013), and Spain. Learning progression has also been an important research model for natural and environmental sciences education (Gunkel et al. 2012). | 围绕GIS在学校中的实施和有效性的主要关注之一是监视地理空间技术对学习的实际影响。换句话说，有没有数字地图，学生会学到更多吗？那学习的程度是什么？在数字地图集设计的开始，人们对诸如ArcGIS Online这样的视觉吸引力和用户友好工具的热情便可见一斑。在几次地理教育会议上，许多教育工作者向学生传达了Web映射界面的动机因素。但是，必须根据经验对地理学习进行比较，以根据课程标准评估有效性。因此，需要可靠的模型和工具来确认以下假设：与传统方法相比，学生使用ADE学习得更成功。作者选择了学习进展模型（该模型是地理教育中学习成果的广受关注的理论框架）来进行数字地图集实施的研究。学习进步一直是一些机构（如国际地理联盟地理教育委员会（Muniz，Solem和Boehm〜2016； Solem等人，2018； Solem等人，2018），美国地理学家协会和国家地理教育委员会（Bednarz，Heffron和Huynh，2013年； Solem，Huynh和Boehm，2014年； Huynh，Solem和Bednarz，2015年； Larsen和表1。使用数字地图集学习气候主题的进展。0级否理解的证据1级学生了解气候概念2级学生可以识别气候区域3级学生了解不同的地理因素如何确定气候4级学生可以确定哪些地理因素对气候定义或多或少地重要5级学生了解某个世界区域受气候变化的影响更大。表2. Dig对城市地理主题的学习进展ital图集。等级0没有理解的证据等级1学生了解城市概念等级2学生可以识别世界上的首都地区等级3学生可以了解不同国家的城市化水平等级4学生可以根据城市化水平识别城市区域等级5学生可以了解城市人口表3。数字地图集介绍了经济主题的学习进展，并解释了城市网络的复杂性。级别0没有理解的证据级别1学生了解全球化概念级别2学生可以确定出口率更高的地区级别3学生可以了解世界上较发达地区排名最高的可达性级别4学生可以确定可达性与交通密度之间的关系级别5学生将理解全球化概念的空间复杂性，即商品和服务的国际交换，也包括资本和信息的国际交换，从而加强了空间依赖性和层次结构。表4：利用数字地图集学习空间不平衡主题的进展。级别0没有理解的证据级别1学生了解人口增长概念级别2学生可以识别人口增长较高的区域级别3学生可以了解相对经济增长（低于平均水平，高于平均水平）级别4学生可以根据经济增长来识别区域，区分第五级学生了解，存在着空间关系，可以解释人口与经济增长之间的联系。表5。使用数字地图集学习空间思维的过程。级别0没有理解的证据级别1学生可以理解原始的地理空间概念，例如身份位置级别2学生可以将空间分布识别为简单的概念级别3学生可以建立地理空间关系并识别地图中的聚类，困难的概念级别4学生可以将地图上的走廊和缓冲区识别为复杂的地理空间概念。5级学生获得了扩展的抽象思维，因为他们可以概括复杂的空间结构，例如层次结构或中心位置78 R. DE MIGUELGONZÁLEZ和ML DELÁZAROTORRES Harrington 2018），欧洲协会（EUROGEO）的地理学家（Zwartjes 2014; Donert等人2016），但也有英国（Weeden 2013）和西班牙的研究人员。学习进展也是自然和环境科学教育的重要研究模型（Gunkel等，2012）。 |
| The Road Map for 21st Century Geography Education Project recommended “that geography education researchers engage in systematic efforts to identify learning progressions in geography both within and across grade bands” and stated that “the Committee believes that empirical research that tests hypothetical learning progressions will advance our understanding of student learning and provide guidance to the design of standards, assessments, and shared tasks and activities” (Bednarz, Heffron, and Huynh 2013, 56–57). This was also applied in Spain in two studies, which helped define the learning progression scale for this particular research on Digital Atlas implementation. Souto, Vercher, and Rodrıguez (2014) obtained some evidence on Selectividad results (equivalent to SAT or ACT for the US or A levels in the UK) applying the revised Structured Observed Learning Outcomes (Anderson and Krathwohl 2013) taxonomy, and adapted to geographical knowledge and skills (Table 6). Other classroom research with middleschool students (De Miguel 2016a) verified the effectiveness of the Digital Atlas for teaching smart cities and improving spatial thinking (Table 7). This table identified the five steps of Bloom’s taxonomy to five learning progression levels of spatial thinking (Golledge, Marsh, and Battersby 2008) and it has been confirmed as a valid and useful empirical tool for obtaining results from the educational implementation of the Digital Atlas, as part of the research described below. | 《 21世纪地理教育路线图》建议“地理教育研究人员应进行系统的努力，以识别年级内和跨年级的地理学习进展”，并指出“委员会认为，检验假设学习进展的实证研究将推动我们的发展。理解学生的学习，并为设计标准，评估以及共享的任务和活动提供指导”（Bednarz，Heffron和Huynh 2013，第56-57页）。在西班牙的两项研究中也应用了此方法，这有助于为Digital Atlas实施这一特定研究定义学习进度量表。 Souto，Vercher和Rodr Iguez（2014）应用修订后的结构化观察学习成果（Anderson和Krathwohl，2013年）分类法，获得了有关选择性结果（美国的SAT或ACT或英国的A级）的一些证据地理知识和技能（表6）。其他与中学生进行的课堂研究（De Miguel 2016a）证明了数字地图集在教授智慧城市和改善空间思维方面的有效性（表7）。该表确定了Bloom的分类法在空间思维的五个学习进展水平上的五个步骤（Golledge，Marsh和Battersby 2008），并且已被确认为从数字地图集的教育实施中获得结果的有效且有用的经验工具，作为下面描述的研究的一部分。 |
| To investigate implementation and effectiveness of the Digital Atlas, the authors defined five scales of five levels as the key instrument for measuring learning outcomes and progressions. This followed an argument from analogy regarding five SOLO levels: one for each thematic section of the Digital Atlas (climate, urban geography, economy, spatial imbalances) plus one for spatial thinking and spatial citizenship (Tables 1–5). In particular, Table 5 combines the joint assessment of learning practices in spatial thinking and spatial citizenship using geoinformation as three highly connected concepts (Shin and Bednarz 2019). The two last items from the questionnaire included spatial-thinking abilities—as aforementioned in Table 7 (spatial patterns, spatial dependences, and so on)—and also spatial citizenship skills such as raising awareness of sustainable ways for urban mobility, civic participation and communication about traffic and transit, engagement in community facilities, etc. | 为了研究数字地图集的实施和有效性，作者定义了五个等级的五个等级，作为衡量学习成果和进步的关键工具。在此之前，有一个类比论证涉及五个SOLO级别：一个针对数字地图集的每个主题部分（气候，城市地理，经济，空间失衡），另一个针对空间思维和空间公民身份（表1-5）。表5特别结合了使用地理信息作为三个高度相关的概念对空间思维和空间公民学习实践的联合评估（Shin和Bednarz 2019）。问卷的最后两个项目包括空间思考能力（如表7所述（空间模式，空间依赖性等））以及空间公民技能，例如提高对城市出行，公民参与和交流的可持续方式的认识有关交通和过境，参与社区设施等 |
| |  |  | | --- | --- | | Table 6. Learning progressions for geographical education. Source: Souto, Vercher, and Rodrıguez 2014, p. 53 | | | SOLO levels | Students’ cognitive tasks | | Pre-structural | Students recognize and remember specific geographic information, but do not know how to develop, organize or structure it. They do not understand what they have studied and simply repeat meaningless information. | | Unistructural | Students can connect simple and obvious spatial ideas but still do not understand the meaning. | | Multistructura | Students connect concepts of different geographical areas but lack the ability to synthesize. Students can solve, apply or calculate graphs (climate, population, etc.) but do not understand the significance of the whole. | | Relational | Students can appreciate the significance of the parts in relation to the whole, develop a general explanation of geographic phenomena, and synthesize and interpret a geographic subject. | | Extended abstract | Students can create principles and generalize. Students prove they not only know the given subject area, but also something beyond it, and they can transfer these principles and criticize, judge, design, improve, etc. | | |  |  | | --- | --- | | 表6.地理教育的学习进度。 资料来源：Souto，Vercher和Rodr Iguez 2014，第9页。 53 | | | 独奏水平 | 学生的认知任务 | | 结构前 | 学生识别并记住特定的地理信息，但不知道如何开发，组织或构造该信息。 他们不了解自己研究的内容，只是重复无意义的信息。 | | 单结构 | 学生可以将简单而明显的空间思想联系起来，但仍然不理解其中的含义。 | | 多元结构 | 学生会联系不同地理区域的概念，但缺乏综合能力。 学生可以求解，应用或计算图表（气候，人口等），但不了解整体的重要性。 | | 关系型 | 学生可以了解各个部分相对于整体的重要性，可以对地理现象进行一般性解释，并可以综合和解释地理主题。 | | 扩展摘要 | 学生可以创造原理并进行概括。 学生证明他们不仅知道给定的学科领域，而且知道它以外的东西，并且他们可以传递这些原理并进行批评，判断，设计，改进等。 | |
| Table 7. Spatial-thinking abilities acquired by students during the instructional intervention on smart cities.  Level 1 Location, measuring distance, layering  Level 2 Overlaying and dissolving, visualization, connecting locations, buffering, scale, comparing maps  Level 3 Assessing similarity, associating and correlating spatially distributed phenomena, regionalizing  Level 4 Forming hierarchies, defining networks, identifying spatial patterns, recalling and representing layouts, evaluating regularity, recognizing spatial distribution, determining clusters  Level 5 Evaluating randomness, determining dispersion, identifying spatial dependences, sketching maps, constructing gradients | 表7.学生在智慧城市的教学干预过程中获得的空间思维能力。  1级位置，测量距离，分层  2级叠加和分解，可视化，连接位置，缓冲，缩放，比较地图  3级：评估相似性，关联和关联空间分布的现象，区域化  级别4形成层次结构，定义网络，识别空间模式，调用和表示布局，评估规则性，识别空间分布，确定聚类  5级：评估随机性，确定离散度，确定空间依赖性，绘制地图，构建渐变 |
| 方法：参与者，仪器和程序 // Methodology: Participants, instrument, and procedure | |
| The study was set in two contexts: a high school and a college of education. The number of secondary students was almost the same (n ¼ 43) as the number of college students (n ¼ 40). The background, ethnicity and gender composition did not vary greatly across the total participants (n ¼ 83), except for the difference between the two groups. One group comprised two classes recruited for this study from tercero de la ESO (equivalent to 9th Grade in the US, i.e., freshman at high school) and the other was one class studying for the Master’s Degree for Teacher Training in Secondary Education. Despite the age difference between these two groups (secondary school students aged 14–15, and master’s degree students usually aged 22), both were intentionally utilized to verify the contradictory status of geography teaching in Spain. As in France, Italy and several Latin American countries, secondary education in Spain does not include a geography course per se, since it is integrated in social sciences. | 该研究是在两种情况下进行的：一所高中和一所教育学院。中学生人数与大学生人数（n¼40）几乎相同（n¼43）。除了两组之间的差异外，所有参与者的背景，种族和性别构成均没有很大差异（n¼83）。一组包括从tercero de la ESO（相当于美国9年级，即高中一年级）招募的两门课程，另一组是攻读中学教育教师培训硕士学位的课程。尽管这两组的年龄有所不同（14至15岁的中学学生和22岁的硕士学位学生），但都故意使用这两者来验证西班牙地理教学的矛盾状况。与法国，意大利和几个拉丁美洲国家一样，西班牙的中等教育本身不包含地理课程，因为它已与社会科学融为一体。 |
| Consequently, geography is taught at the same time as history, art history and civic education, although the national curriculum includes more geographical content in tercero de la ESO (9th grade in the US), while mostly history content are in the curriculum in cuarto de la ESO (10th grade in the US). As this situation continues in undergraduate programs, most people starting a master’s degree to become a secondary school teacher of social sciences only studied history at high school or in undergraduate programs. In other words, future teachers of social sciences (geography and history) stop learning geography from the age of 14–15 until the beginning of the master’s degree program, when they take two courses: one of general geography (physical, human and regional) and one of geographical education and didactics (De Miguel 2016a). This is the case not only for 40-person study sample but also for thousands of students enrolled in postgraduate teacher-training programs at any Spanish university | 因此，尽管国家课程在tercero de la ESO（美国9年级）中包含了更多的地理内容，但地理课程与历史，艺术史和公民教育同时进行，而cuarto de la ESO（美国10年级）。随着这种情况在本科课程中的持续发展，大多数人开始攻读硕士学位，成为社会科学的中学教师，只在高中或本科课程中学习历史。换句话说，未来的社会科学老师（地理和历史）将从14-15岁开始学习地理，直到硕士学位课程开始，届时他们将学习两门课程：一门普通地理（自然，人文和地区）以及地理教育和教学法之一（De Miguel 2016a）。这不仅适用于40人的学习样本，而且适用于西班牙任何一所大学的研究生教师培训课程的数千名学生 |
| The researchers obtained data through five questionnaires, one for each of the five aforementioned categories: climate, urban geography, economy, spatial imbalances and spatial thinking. As each questionnaire included five progressive items, in accordance with the criteria given in Tables 1–5, checking the learning level and learning progression outcomes was easy. Consequently, each student (both graduate and secondary, n ¼ 83) had to complete 25 items twice (pre- and post-test), which provided 4,150 empirical data items. The questionnaires were validated in a quantitative-qualitative mixed sequential approach. First, the questionnaire was presented and discussed at several conferences on geographical education organized by the aforementioned institutions: Commission on Geographical Education of the International Geographical Union, AAG Annual Meeting, EUROGEO Conference, Spanish Geographers Conference. The ESRI educational team also surveyed the Digital Atlas, its implementation and the questionnaire. Instrument reliability and validity were addressed by the Cronbach’s alpha quantitative index. The responses to the Likert-scale items indicated a strong internal consistency (Cronbach’s a ¼ 0.85). | 研究人员通过五份调查表获得了数据，其中每一个涉及上述五个类别：气候，城市地理，经济，空间失衡和空间思维。由于每个调查表都包含五个渐进项，根据表1-5中给出的标准，检查学习水平和学习进度结果很容易。因此，每个学生（研究生和中学，每人¼83）必须两次完成25个项目（测试前和测试后），其中提供了4,150个经验数据。问卷以定量-定性混合顺序法进行了验证。首先，在上述机构组织的几次地理教育会议上介绍并讨论了调查表：国际地理联盟地理教育委员会，AAG年会，EUROGEO会议，西班牙地理学家会议。 ESRI教育团队还调查了数字地图集，其实施情况和调查表。仪器的信度和效度通过Cronbach的alpha定量指数解决。对李克特量表项目的回答显示出很强的内部一致性（Cronbach为¼0.85）。 |
| The questionnaire was first administered as a pretest after teaching geography with analog or conventional educational resources, such as a printed atlas, textbooks and wall maps in a more teacher-centered way of teaching. The second administration (post-test) consisted of completing the questionnaire after several learning activities with the Digital Atlas. It also helped in obtaining empirical data to measure learning progressions absolutely, from the first to the fifth established levels, and relatively, seeking differences between the pre- and the post-test, i.e., between an analog and a digital approach for teaching and learning geography. | 在使用类似的或常规的教育资源（例如印刷的地图集，教科书和挂图）以地理老师为中心的教学方式进行地理教学后，首先将问卷作为预测试进行管理。 第二个管理部门（测试后）是在与Digital Atlas进行几次学习活动之后完成调查表。 它还有助于获得经验数据，以绝对地衡量从第一个到第五个既定水平的学习进度，并相对地寻求测试前和测试后之间的差异，即在模拟和数字方法之间进行教与学 地理。 |

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| 结果 // Result | |
| 全球结果 // Global results | |
| The overall result from the data analysis showed an average student score of 3.40 (based on the five levels of SOLO taxonomy in Table 6) in the pretest versus a score of 4.31 in the post-test. This means an increase of 0.91 from nondigital to digital geography teaching (18.2% increase). These differences are further accentuated in the secondary school students: 2.95 in the pretest versus 4.02 in the post-test (an increase of 1.07, 21.4%). Among the graduate students, the scores were 3.88 (pretest) versus 4.61 (post-test), which is an increase of 0.73 (14.6%). First aggregate data showed that the graduate students obtained a higher level of knowledge, but that the secondary school students gained more benefits from learning using the Digital Atlas. The number of students with improved learning after the post-test confirms this: 62% of the total participants increased at least one level in any of the five questionnaires versus 38% of students that did not demonstrate any increase between the pre- and post-tests. Almost two out of three participants in the empirical research confirmed the effectiveness of the Digital Atlas after its implementation. These data also differ for the secondary school students (70% show an improvement versus 30% with the same score) and the graduate students (53% show an improvement versus 47% with the same score). | 数据分析的总体结果显示，前测平均学生得分为3.40（基于表6中的SOLO分类的五个级别），而后测平均得分为4.31。这意味着从非数字地理教学到数字地理教学的增长为0.91（增长了18.2％）。这些差异在中学生中更加突出：测试前2.95，测试后4.02（增加1.07，21.4％）。在研究生中，分数分别为3.88（测试前）和4.61（测试后），增幅为0.73（14.6％）。最初的汇总数据显示，研究生获得了更高水平的知识，而中学生从使用数字地图集的学习中获得了更多好处。测验后学习有所改善的学生人数证实了这一点：在五份问卷中，有62％的参与者至少增加了一个水平，而在测验前后之间没有表现出任何增加的学生为38％。测试。实证研究的三分之二的参与者证实了数字地图集实施后的有效性。这些数据对于中学生（70％的学生成绩有所改善，而相同分数的30％）和研究生（53％的学生成绩有所改善，相同分数的47％）也有所不同。 |
| The student distribution of learning outcomes reveals these trends: 14.5% of the graduate students (n ¼ 40) attained the maximum score, level 5, for all the questionnaires, that is, extended abstract knowledge and skills in climate, urban geography, economy, spatial imbalances and spatial thinking. None of the secondary school students (n ¼ 43) obtained the top score of 5 in the five questionnaires, but three (6.9%) acquired a score of 5 in four questionnaires plus a level 4 in the fifth questionnaire, which makes an average score of 4.8 for these three students. On the other side of the scale, no graduate student obtained a score below level 3 (multistructural) and only one secondary school student obtained an average score of level 2.6 (between unistructural and multistructural). The vast majority of the graduate students (92.5%) exceeded relational knowledge (level 4) while the smaller majority of the secondary school students (55.8%) exceeded this relational knowledge (level 4), although 83.7% of the school students achieved a score above level 3.4 (Table 8). | 学生学习成果的分布揭示了这些趋势：所有问卷中，有14.5％的研究生（n¼40）达到最高分，达到5级，即在气候，城市地理，经济，空间失衡和空间思维。在这五份问卷中，没有哪个中学生（n¼43）获得最高分5分，但是在三份问卷中，有三名（6.9％）获得了5分，在第五份问卷中获得了4级，这是平均分这三个学生的4.8。在量表的另一侧，没有研究生获得低于3级（多级结构）的分数，只有一名中学生获得平均2.6级（单级和多级结构）的平均分数。绝大多数研究生（92.5％）超过了相关知识（4级），而较小部分的中学生（55.8％）超过了相关知识（4级），尽管83.7％的学生获得了相关知识高于3.4级（表8）。 |
| Concerning standard deviation, the amount of variation or dispersion in the pretest (r ¼ 0.85) is a bit higher than in the post-test (r ¼ 0.58). This confirms the validity of the results and indicates that the scores after doing activities with the Digital Atlas tend to be closer to the mean. This is especially evident for the graduate students, although other standard deviation results are not much higher, so scores are not really spread out over the range of values (Table 9). | 关于标准偏差，预测试中的变化或分散程度（r¼0.85）比后测试中的差异（r¼0.58）要高一些。 这证实了结果的有效性，并表明在使用Digital Atlas进行活动后的得分倾向于接近平均值。 对于研究生来说，这一点尤为明显，尽管其他标准差的结果并不高，因此分数并未真正分布在各个数值范围内（表9）。 |
| 地图和问卷调查结果 // Results by map and questionnaire | |
| The results disaggregated by questionnaire and map (Table 10) indicate that climate obtained the highest score (n ¼ 83: 4.49) per participant in all groups for the post-test, followed by spatial imbalances (4.44), spatial thinking (4.31), economy (4.29) and urban geography (4.01). Although spatial thinking is one of the most difficult topics in research education—as expressed by many of the aforementioned authors in their publications on spatial-ability tests, for example Lee and 80 R. DE MIGUEL GONZÁLEZ AND M. L. DE LÁZARO TORRES Bednarz 2012—research proves that the Digital Atlas is more effective in this particular aspect. Data confirm that spatial thinking had the lowest scores in the pretest (2.90) and exceeded the economy and urban geography topics at the end of the intervention, thus implying the highest improvement difference between the pre- and post-tests: 1.41 (n ¼ 83), 1.25 (n ¼ 40) and 1.56 (n ¼ 43). On the contrary, climate and spatial imbalances showed the lowest improvement due to their high initial (pretest) score, for example, 0.42 points of difference between both climate tests for n ¼ 40. In other words, the Digital Atlas resulted far more effective for teaching spatial thinking to school students than teaching climate to graduate students. Furthermore, the fact that the average score for the fifth questionnaire was 4.31 (n ¼ 83), but 4.60 for graduate students and 4.04 for freshman secondary students, means that the vast majority of participants (83%) attained one of the two items—levels four and five—also related to spatial citizenship. And, in particular, 69% of graduate students (adults) achieved five out of five items, while only 38% of secondary school students did. | 通过问卷调查和地图分类的结果（表10）表明，在后测试中，气候在所有组中每个参与者的得分最高（n¼83：4.49），其次是空间失衡（4.44），空间思维（4.31），经济（4.29）和城市地理（4.01）。尽管空间思维是研究教育中最困难的主题之一，正如许多前述作者在其空间能力测试的出版物中所表达的那样，例如Lee和80 R. DE MIGUELGONZÁLEZ和ML DELÁZAROTORRES Bednarz 2012年，证明了数字地图集在此特定方面更有效。数据证实，空间思维在预测试中得分最低（2.90），并且在干预结束时超出了经济和城市地理主题，因此意味着预测试和后测试之间的改进差异最大：1.41（n¼83） ），1.25（n¼40）和1.56（n¼43）。相反，由于气候和空间失衡的初始（预测试）得分较高，因此改善程度最低，例如，两次气候测试之间的差异为n¼40，相差0.42点。换句话说，数字地图集的结果要有效得多。向学生讲授空间思维比向研究生讲授气氛。此外，第五份问卷的平均分数为4.31（n¼83），而研究生为4.60，新生为4.04，这意味着绝大多数参与者（83％）达到了以下两项之一：第四和第五级-也与空间公民身份有关。特别是，有69％的研究生（成人）达到了五分之五的水平，而只有38％的中学生做到了。 |
| The number of learning progression levels improved by the students after implementing the Digital Atlas also confirms this trend. Table 9 shows that very few students from both groups, secondary and graduates, (16.9%) failed to experience any increase between the pre- and post-tests in the spatial-thinking questionnaire. The other topics with the highest rate evidence of no improvement between the preand post-tests were: 48.2% climate, 45.8% spatial imbalances, 43.4% economy, and 38.6% urban geography. Furthermore, spatial thinking had the highest rate of evidence of students improving three or more levels between the pre- and posttests (12%) versus any other topics (5% of students improved three or more levels in climate, urban geography and spatial imbalances). | 实施数字地图集后，学生提高的学习进步水平数量也证实了这一趋势。 表9显示，来自两组的学生（中学和研究生）中，很少有（16.9％）的学生在空间思考问卷的测试前和测试后之间没有任何增加。 其他在测试前和测试后没有改善的最高研究主题是：48.2％的气候，45.8％的空间失衡，43.4％的经济和38.6％的城市地理。 此外，与其他任何主题相比，空间思维有最高的证据表明学生在测试前和测试后提高了三个或更多水平（12％）（在气候，城市地理和空间失衡方面，有5％的学生提高了三个或更多水平） 。 |
| 讨论区 // Discussion | |
| Results provide evidence for the two main research questions discussed at the beginning of this article. Digital Atlas is a powerful tool to learn geography as it fosters more meaningful learning than conventional instructional resources. Besides this, Digital Atlas help in the goal of balance between spatial thinking, geographical knowledge and spatial citizenship. The responses to the questionnaires suggest that both school and higher education participants experienced effective learning from implementing the Digital Atlas, although this was more marked in the secondary school geography students. Nevertheless, this approach has also proved to be an important instrument for consolidating knowledge and raising awareness during teacher training, especially in the spatial citizenship questions. Although the adults obtained a higher learning outcome level than the teenagers (in absolute terms of knowledge and skills acquisition), an indisputable outcome of this research is that relative learning, that is, an increase in learning progressions and cognitive tasks based on the five Structured Observed Learning Outcomes (SOLO) categories, is most important in school students. | 结果为本文开头讨论的两个主要研究问题提供了证据。数字地图集是学习地理的有力工具，因为它比传统的教学资源能促进更有意义的学习。除此之外，数字地图集还有助于实现空间思维，地理知识和空间公民权之间的平衡。对问卷的答复表明，学校和高等教育参与者都从实施数字地图集方面获得了有效的学习，尽管这在中学地理学生中更为明显。但是，这种方法也已被证明是在教师培训期间尤其是在空间公民权问题中巩固知识和提高认识的重要工具。尽管成年人获得的学习成果水平比青少年要高（就知识和技能获得的绝对意义而言），但这项研究的无可争议的结果是相对学习，即基于五种结构性学习的学习进展和认知任务的增加观察到的学习成果（SOLO）类别在学校学生中最为重要。 |
| The experience was also positive for most participants. Notwithstanding the size of the sample or the questionnaire structure, two thirds of the students (graduate and high school) demonstrated improved geography learning, but particularly the 9th grade students. One reason for this might be the use of geospatial technologies as they are more visual, facilitate learning-by-doing processes, and, therefore, are more motivating for geography learners, who tend to be more comfortable working and living with multimedia devices. | 对于大多数参与者来说，这次经历也是积极的。 尽管样本量或问卷结构很大，但三分之二的学生（研究生和高中）显示出地理学习的改善，特别是9年级的学生。 原因之一可能是使用地理空间技术，因为它们更加可视化，简化了边做边学的过程，因此对地理学习者更具激励作用，他们倾向于更舒适地使用多媒体设备工作和生活。 |
| Results also reveal the possibilities of this geospatial approach in a comprehensive teaching model as it was useful for pupils seeking excellence and for students with learning difficulties, and, in particular, with difficulties in acquiring spatial thinking. Otherwise, a large percentage of participants in both categories reached a medium-high learning progression level. Since over 90% of the graduate students were able to create geographical principles, generalize, and transfer those principles from the specific topic to a large geographical process, their status was between upper relational and extended abstract. Over 80% of secondary school participants also exceeded the multistructural level, as they can discern spatial relationships, provide a general explanation of geographic phenomena, and synthesize a geographic subject. However, in some subjects, such as urban geography or economy, students show more difficulty in understanding the complexity of spatial organization | 结果还揭示了这种地理空间方法在综合教学模型中的可能性，因为它对寻求卓越的学生和学习困难的学生特别有用，尤其是在获得空间思维方面的困难的学生。 否则，这两个类别中的很大一部分参与者都达到了学习发展的中高水平。 由于超过90％的研究生能够创建地理原理，进行概括并将这些原理从特定主题转移到较大的地理过程中，因此他们的地位介于较高的关系和扩展的抽象之间。 超过80％的中学参与者还超过了多层次的水平，因为他们可以辨别空间关系，提供对地理现象的一般解释并综合地理学科。 但是，在某些学科中，例如城市地理学或经济学，学生在理解空间组织的复杂性方面表现出更大的难度 |

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| 结论 // Conclusion | |
| The study conducted at a high school and a university has provided a deeper understanding of the benefits of using WebGIS for geography teaching and learning. The questionnaires were completed by 83 people to show their learning progressions without (pretest) and with (post-test) geospatial technologies for the purpose of comparing learning outcomes. This research has shown that a rational implementation of the Digital Atlas is more effective than conventional methods of teaching geography. It is more effective in absolute terms for graduate students (they achieve the highest levels), and more effective in relative terms for secondary school students (they achieve higher learning progressions). The more WebGIS is used, the longer the learning line progression is. | 在高中和大学中进行的这项研究对使用WebGIS进行地理教学带来的好处有了更深入的了解。 问卷由83人完成，以显示他们在没有（测试前）和（测试后）地理空间技术的情况下的学习进度，目的是比较学习成果。 这项研究表明，合理实施数字地图集比传统的地理教学方法更有效。 从绝对意义上说，它对研究生更有效（他们达到最高水平），对相对而言对中学生更有效（他们达到更高的学习进度）。 使用的WebGIS越多，学习线的进度就越长。 |
| The research has some limitations: geography is not compulsory in Spain at high school in 10th, 11th or 12th grades; secondary school teachers only use the Digital Atlas occasionally for particular lessons (versus questionnaires throughout the entire curriculum); the graduate students have a weak geographical background; the shortage of empirical researchers; and the lack of teacher engagement at high school. A larger sample could have broadened the number of participants, and, therefore, the statistics. Nevertheless, the visual appeal of the maps in the Digital Atlas, and the implementation of the learning-by-doing and independent-task method increased the motivation of almost all participants. In the case of the graduate students in preservice teacher training, the experience proved extremely positive. Many stated they would need more training (pre and in-service) to acquire suitable geospatial-technology skills to master WebGIS as a key instructional resource in their future professional development. | 该研究存在一些局限性：西班牙高中10年级，11年级或12年级的地理不是必修课；中学教师仅偶尔使用Digital Atlas进行特定课程的学习（相对于整个课程中的问卷调查）；研究生地理背景薄弱；经验研究人员的短缺；以及缺乏高中教师的参与度。较大的样本本来可以扩大参与者的人数，因此也可以扩大统计数字。尽管如此，数字地图集中地图的视觉吸引力以及边做边学和独立任务方法的实施增加了几乎所有参与者的动力。在研究生接受职前教师培训的情况下，经验证明是极为积极的。许多人表示，他们将需要更多的培训（预培训和在职培训）以获取合适的地理空间技术技能，以掌握WebGIS作为其未来专业发展中的重要指导资源。 |
| This study has demonstrated the effectiveness of geospatial technologies in enhancing students’ knowledge, skills and values. Thus, the research confirms that WebGIS has many educational advantages for students and teachers at secondary schools, especially in geographical education. Quantitative research findings have also shown how the three key components in geographical education—spatial thinking, geographical knowledge and spatial citizenship— have developed, especially in the case of geographical knowledge. Since the Spanish curriculum is rigid and disciplinefocused, teachers and students are more used to performing activities related to descriptive geographical knowledge than to learning-by-doing spatial thinking or spatial citizenship tasks | 这项研究证明了地理空间技术在增强学生的知识，技能和价值方面的有效性。 因此，研究证实，WebGIS对中学的学生和教师具有许多教育优势，尤其是在地理教育方面。 定量研究发现还表明，地理教育的三个关键组成部分（空间思维，地理知识和空间公民身份）是如何发展的，特别是在地理知识的情况下。 由于西班牙语课程是严格的和以学科为重点的，因此教师和学生更习惯于执行与描述性地理知识相关的活动，而不是边做边学的空间思维或空间公民任务 |
| Despite these limitations, the research has managed to answer the initial questions and, in particular, show how geospatial technologies contribute to spatial citizenship to raise awareness of spatial values, civic engagement, and democratic participation. This research illustrated a balance in student understanding of the three components in the five analysis categories. All participants experienced higher learning progressions with geospatial technologies in spatial thinking, geographical knowledge (in particular through powerful urban and economic geography concepts), but also in spatial citizenship. Climate change and spatial imbalances questionnaires demonstrated spatial empathy among students for geographical and social problems (for example, temperature rises and social injustices by comparing two territories) and, consequently, they have considered Webmapping as an empowering tool for expressing and disseminating their own ideas, solutions or suggestions to improve spatial conditions. Some maps from the Digital Atlas were even used later by teachers and students to raise awareness of the UN 2030 Sustainable Development Goals. | 尽管存在这些局限性，该研究仍设法回答了最初的问题，尤其是显示了地理空间技术如何促进空间公民身份，以提高人们对空间价值，公民参与和民主参与的认识。这项研究说明了学生对五个分析类别中三个组成部分的理解之间的平衡。所有参与者都在空间思维，地理知识（尤其是通过强大的城市和经济地理概念）以及空间公民身份的地理空间技术方面经历了更高的学习进度。气候变化和空间失衡问题调查表表明，学生对地理和社会问题（例如，通过比较两个地区的气温上升和社会不公正现象）存在同情心，因此，他们认为Webmapping是表达和传播自己的思想的授权工具，解决方案或建议，以改善空间条件。甚至后来，教师和学生还使用了数字地图集的一些地图，以提高人们对联合国2030年可持续发展目标的认识。 |
| Connections between geospatial technologies and spatial awareness could be a supplementary research topic. Further qualitative research (interviews, focus groups, etc.) might help in understanding why the Digital Atlas allows students to gain experience through constructivist learning. Spatialthinking ability tests or other standardized tests (such as the AP Human Geography exam) can provide more easily quantitative data, but spatial citizenship research would require another approach. These lines of research and others—for example, inquiring in detail why one out of three could not gain any benefit from using the Digital Atlas—will open new possibilities for future instructional interventions with the Digital Atlas, or any other similar WebGIS tool. | 地理空间技术与空间意识之间的联系可能是一个补充研究主题。 进一步的定性研究（访谈，焦点小组等）可能有助于理解数字地图集为何允许学生通过建构主义学习获得经验。 空间思维能力测试或其他标准化测试（例如，AP人文地理学考试）可以提供更容易的定量数据，但是空间公民研究需要另一种方法。 这些研究和其他研究（例如，详细询问为什么三分之一的人不能从使用Digital Atlas中获得任何收益）将为Digital Atlas或任何其他类似的WebGIS工具将来的教学干预提供新的可能性。 |
| This article contributes to the body of empirical evidence of meaningful, concrete and measurable learning, and reinforces research on geospatial-learning technologies. While this research on the Digital Atlas obtained similar results to the papers mentioned earlier, (Baker et al. 2015; Bednarz, Heffron, and Huynh 2013), it strengthens the argument for a structured methodology to conduct reliable research, in this case, both for learning activities with students (inquirybased instructional learning approach) and for the research design itself (learning progressions). | 本文为有意义的，具体的和可衡量的学习提供了经验证据，并加强了对地理空间学习技术的研究。 虽然对数字地图集的这项研究获得了与之前提到的论文类似的结果（Baker等人，2015年； Bednarz，Heffron和Huynh，2013年），但它加强了结构化方法论进行可靠研究的论点，在这种情况下，两者 用于与学生的学习活动（基于查询的教学方法）以及用于研究设计本身（学习进度）。 |
| As for the students that did not experience benefits after using the Digital Atlas, this seemed a result of rejection of the spatial technologies by students and trainee teachers more used to paper atlases, textbooks or transmissive lectures. Difficulties, biases and misconceptions could be causes of the lack of effectiveness. This merits further research, perhaps considering interoperability between mobile apps/ 82 R. DE MIGUEL GONZÁLEZ AND M. L. DE LÁZARO TORRES devices and WebGIS, which is increasingly useful for fieldwork and outdoor learning. | 对于使用数字地图集后没有收益的学生，这似乎是学生和实习教师拒绝使用空间技术的结果，他们更习惯于撰写地图集，教科书或透射式演讲。 困难，偏见和误解可能是缺乏效力的原因。 这值得进一步研究，也许考虑到移动应用程序/ 82 R. DE MIGUELGONZÁLEZ和M. L. L LZAZARO TORRES设备与WebGIS之间的互操作性，这对于野外作业和户外学习越来越有用。 |
| Nonetheless, it is evident that, in the last decade, an increased awareness of the educational benefits of geospatial technologies in the classroom, especially in secondary education as they offer such a wide diversity of motivating instructional resources, strategies, and methodologies for learners exists among the geography education community. The US Road Map for Geography Education and the IGU International Charter on Geographical Education underline the challenges geographical education faces in the 21st century, in particular, expanding skills compared with many decades ago. How to deal with this geospatial-technology boom in a smart way is key to achieving an integral geographical education, as this research has tried to illustrate with the use of the Digital Atlas. | 尽管如此，很明显，在过去的十年中，人们越来越意识到地理空间技术在课堂上的教育益处，尤其是在中学教育中，因为地理空间技术为学习者提供了如此广泛的激励性教学资源，策略和方法， 地理教育界。 美国地理教育路线图和IGU国际地理教育宪章强调了21世纪地理教育面临的挑战，尤其是与几十年前相比，技能的扩展。 如何巧妙地应对这一地理空间技术的繁荣，是实现完整的地理教育的关键，正如本研究试图通过使用数字地图集来说明的那样。 |