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DIGITAL TOOLS IN TEACHING INNOVATIVE URBAN DEVELOPMENT IN SECONDARY SCHOOL GEOGRAPHY

This article presents a theoretical review of international experience in the use of digital tools for teaching innovative urban development in secondary school geography. The relevance of the study is determined by increasing urbanization, the expansion of the smart city concept, the growing significance of sustainable development goals, and the need to develop students' spatial thinking, digital literacy, and civic competencies in the study of urban topics. The study was designed as a descriptive and analytical theoretical investigation based on a structured review of peer-reviewed publications indexed in Scopus, Web of Science, ERIC, and Google Scholar. The review made it possible to identify the main groups of digital tools used in teaching urban topics, including online maps and WebGIS, open urban data resources, urban simulators, mobile AR/VR tools, educational platforms, and citizen science applications. On this basis, the article proposes a typology of digital tools according to their functional and didactic characteristics and formulates the main methodological principles for teaching innovative urban development in school geography. In the context of Kazakhstan, national platforms such as BilimAll and BilimLand are considered as potential digital environments for adapting international pedagogical experience to the local curriculum. The scientific novelty of the study lies in the pedagogical systematization of digital tools for teaching

innovative urban development and in the development of a conceptual basis for their integration into school geography.

Keywords: school geography, innovative urban planning, digital tools, WebGIS, AR/VR, spatial citizenship, BilimAll.

Introduction

The rapid urbanization of the twenty-first century, the expansion of the "smart city" concept, and the growing relevance of the Sustainable Development Goals, particularly SDG 11, "Make cities and human settlements inclusive, safe, resilient and sustainable", require school geography to reconsider both its content and its teaching approaches. In contemporary educational discourse, the city is understood not merely as a type of settlement, but as a complex socio-spatial system shaped by innovation, digital infrastructure, environmental sustainability, mobility, and civic participation. Explaining such multidimensional processes in school geography calls for the simultaneous development of students' spatial thinking, digital literacy, and data interpretation skills [1; 2].

In recent years, digital tools have become increasingly important in geography education. Previous studies show that the pedagogically grounded use of digital technologies can enhance the visualization of cartographic material, support the interpretation of spatial data, and increase students' engagement in learning [1; 2; 8]. Among the most widely discussed tools are mobile learning applications, online educational platforms, geographic information systems (GIS), web-based GIS, web mapping, remote sensing resources, and augmented and virtual reality technologies [1; 3; 4; 6]. In particular, web GIS and web mapping make spatial analysis more accessible at the school level by enabling students to work with authentic geographic data [4–6]. This contributes to the development of spatial thinking, critical analysis, and geographical awareness [4–9]. At the same time, AR and VR tools can facilitate the understanding of complex spatial phenomena through visualization and immersion, especially when they are supported by clear pedagogical guidance and age-appropriate learning tasks [3; 18].

These opportunities are especially relevant for teaching topics related to innovative urban development. Such topics include smart infrastructure, green and blue urban spaces, sustainable transport systems, data-informed urban planning, and forms of public participation associated with citizen science [2; 9; 10]. In this context, urban education should not be limited to the transmission of factual information about cities. It should also foster students' ability to analyze urban processes critically, interpret spatial information, and understand the relationships between technological innovation, sustainability, and civic responsibility [2; 10].

An important conceptual basis for this approach is the idea of spatial citizenship. This perspective links the use of digital geomedial and geoinformation tools with the development of students' critical understanding of urban space, spatial justice, and participatory practices [11; 12]. Through activities related to citizen science and digital mapping, students can engage with real urban issues, collect and interpret data, and discuss possible solutions in socially meaningful ways [13]. Thus, teaching innovative urban development in school geography should be viewed as a process that combines subject learning with the development of spatial-civic competencies, digital ethics, and public awareness [11–13].

At the same time, the existing literature remains fragmented. Many studies focus on the educational potential of individual technologies, such as AR applications, GIS tools, or mobile platforms, whereas the broader issue of how digital tools can be systematically integrated into the teaching of urban topics in school geography remains insufficiently conceptualized [1; 4; 6; 8; 10]. In particular, the concept of innovative urban development has not yet been sufficiently adapted to the logic of school geography, the age characteristics of secondary school students, and the didactic requirements of classroom instruction. Although the pedagogical foundations for technology integration are widely discussed through the TPACK framework and broader approaches to teacher knowledge, subject-specific conceptual models for organizing digital instruction around urban development content in geography education are still poorly developed [14; 15].

This issue is particularly relevant in the educational context of Kazakhstan, where national digital platforms such as BilimAll, BilimLand, and Daryn. Online are increasingly incorporated into school teaching [19; 20]. In the present study, BilimAll is considered not as an object of empirical evaluation, but as an illustrative digital environment through which the adaptation of international pedagogical approaches to the national curriculum context can be discussed [19; 20]. From this perspective, the problem is not limited to the availability of digital resources. Rather, it concerns the lack of a clearly articulated typology of digital tools suitable for urban topics, as well as the absence of a coherent conceptual framework linking educational goals, content, digital resources, student activities, and expected learning outcomes.

The aim of this study is to systematize digital tools used in teaching innovative urban development in secondary school geography and to propose a conceptual model for their pedagogical integration. To achieve this aim, the study addresses the following objectives: to analyze the scholarly and methodological literature on digitalization in geography education and urban learning; to identify the didactic potential of digital tools relevant to urban development topics; to develop a typology of such tools; and to formulate a conceptual model for their application

in school geography. The scientific novelty of the study lies in the pedagogical systematization of digital tools for teaching innovative urban development, the development of a typology of resources oriented toward urban content, and the formulation of conceptual foundations for their adaptation to the national digital educational environment.

Materials and Methods

This study is theoretical in nature and is based on a structured review of scholarly and methodological sources, followed by a conceptual synthesis of the results. The methodological design was aimed not at empirically testing the effectiveness of a specific digital platform, but at systematizing existing approaches to the use of digital tools in teaching innovative urban development in secondary school geography and at developing a conceptual model for their pedagogical integration [16; 17].

The methodology included two interrelated levels. The first level was a structured literature review focused on international research devoted to geography education in digital environments. The review covered studies on mobile learning, educational applications, online learning platforms, GIS, web-based GIS, web mapping, augmented and virtual reality, digital geomedia, and citizen science tools used in geography and sustainability education [1–10; 18]. Particular attention was paid to publications addressing the didactic potential of these tools for the development of spatial thinking, digital literacy, critical analysis, and civic engagement in the study of urban processes [2; 8–13].

The second level consisted of conceptual synthesis. At this stage, the reviewed studies were interpreted through a set of theoretical approaches relevant to geography education and digital pedagogy, including pedagogical content knowledge, technological pedagogical content knowledge, and spatial citizenship [11; 12; 14; 15]. This made it possible to identify the main pedagogical principles for teaching innovative urban development with digital tools and to formulate a conceptual model linking educational goals, thematic content, digital resources, learning activities, and expected outcomes.

The selection of sources was guided by several criteria. Publications were included if they: (1) addressed the use of digital tools in geography, environmental, or sustainability education; (2) had clear methodological or conceptual relevance for school or secondary education, or could reasonably be adapted to that level; (3) examined tools applicable to the teaching of urban topics, spatial analysis, or civic participation; and (4) contributed to the understanding of pedagogical functions of digital resources rather than only their technical characteristics [1–10; 16; 17]. Works with a narrowly technical focus and no clear educational relevance were not prioritized.

The analytical procedure involved several stages. First, relevant international publications and methodological materials were identified and grouped by topic. Second, the selected sources were analyzed in terms of the educational functions of digital tools. Third, the identified tools were classified according to their dominant didactic role in teaching innovative urban development. Fourth, on the basis of this classification and the reviewed theoretical approaches, a conceptual model of digital teaching in school geography was developed [11; 12; 14–17].

To relate the conceptual results to the educational context of Kazakhstan, national digital platforms were considered as examples of possible implementation environments. In this article, BilimAll is treated not as an object of empirical evaluation, but as an illustrative digital platform whose functional capabilities can be compared with the elements of the proposed conceptual model [19; 20]. Such a comparison makes it possible to discuss how internationally recognized pedagogical approaches may be adapted to the national digital educational environment without making claims about measured classroom effectiveness.

Results and Discussion

The review of international scholarly and methodological sources showed that the teaching of urban topics in geography with the use of digital tools is most often associated with such thematic areas as sustainable cities, transport systems, urban ecosystems, smart environments, and public participation [1–4; 6–10]. The analyzed publications demonstrate that digitalization of geography education is not limited to the transfer of content into electronic form; rather, it changes the logic of learning activities by shifting students from the role of passive recipients of information to active interpreters of spatial data and participants in inquiry-based learning [1; 2; 8].

The reviewed studies mainly focus on secondary school students, university students in teacher education, and pre-service geography teachers, whereas primary school applications remain less represented [1; 3; 4; 8; 11]. This pattern can be explained by the conceptual complexity of urban topics and by the higher-order learning activities typically associated with digital tools, including data interpretation, critical reflection, evidence-based reasoning, and problem-oriented analysis [2; 8; 11–13]. As a result, urban topics in school geography are increasingly presented not only as a subject field but also as a context for developing broader educational outcomes, such as environmental awareness, social responsibility, and understanding of the common good [2; 9; 10].

Another important trend identified in the literature is the growing connection between digital geography education and spatial citizenship. In this perspective, digital tools are used not only for visualization and information access, but also for the development of students' ability to interpret urban space critically, identify issues

of accessibility and inequality, and reflect on forms of civic participation in urban life [11–13]. This makes the teaching of innovative urban development particularly suitable for interdisciplinary and value-oriented learning in school geography.

The analysis made it possible to systematize digital tools used in teaching innovative urban development into several groups according to their dominant didactic functions.

The first group includes online maps, GIS, web-based GIS, and web mapping tools. These resources provide opportunities for spatial visualization, comparison of territorial patterns, overlaying thematic layers, and conducting basic spatial analysis [4–9]. Their key pedagogical value lies in the development of spatial literacy, evidence-based reasoning, and the ability to formulate conclusions using cartographic and geospatial materials. In classroom practice, such tools are especially relevant for topics related to transport accessibility, urban expansion, environmental risks, land use, and the spatial structure of cities.

The second group comprises open urban data resources and digital databases. These tools make it possible to work with official statistics, environmental indicators, demographic information, and infrastructure-related data. From a didactic point of view, they support the formation of data literacy, source criticism, and academic integrity, since students must interpret, compare, and evaluate the reliability of data used in urban analysis [2; 8–10]. In addition, this group of tools has a strong civic and ethical dimension, as it helps students reflect on questions of inequality, access to services, environmental justice, evidence-based decision-making.

The third group includes urban modeling and simulation tools, including educational gaming environments. These tools enable students to explore urban development scenarios by changing variables such as housing density, transport organization, green space distribution, or environmental constraints [9; 10]. Their pedagogical potential lies in the development of systems thinking, forecasting skills, and informed decision-making. Through scenario-based tasks, students learn to understand the interdependence of economic, ecological, and social factors and to evaluate possible trade-offs between them.

The fourth group consists of augmented reality (AR), virtual reality (VR), and location-based mobile solutions [3; 7; 18]. These tools create immersive and place-based learning situations that can make complex spatial concepts more visible and meaningful. Their didactic significance is connected with visualization, contextualization of abstract content, and increased learner engagement. At the same time, their effective educational use requires pedagogical scaffolding, age-appropriate task design, and attention to accessibility, health-related time limits, and digital safety.

The fifth group includes citizen science, collaborative mapping, and public participation platforms [11–13]. These tools support forms of learning in which students engage in urban monitoring, environmental observation, social mapping, or community-based data collection. Their main educational value lies in fostering civic engagement, social responsibility, volunteer culture, and digital ethics. In addition, they are particularly important for operationalizing the idea of spatial citizenship in school geography, since they connect geographical knowledge with participation in socially meaningful practices.

Taken together, these groups of tools reveal different dimensions of innovative urban development content. GIS and web mapping tools primarily support spatial analysis; open data tools strengthen evidence-based interpretation; modeling tools support systemic reasoning and informed choice; AR and VR increase the visibility and contextual understanding of urban processes; and citizen science platforms promote participation and spatial-civic awareness. On this basis, digital tools can be viewed not as isolated technologies, but as pedagogically differentiated resources that contribute to different learning outcomes in school geography.

To relate the proposed typology to the educational context of Kazakhstan, the national platform BilimAll was considered as an illustrative digital environment for the possible implementation of urban geography content [19; 20]. In the present study, the platform is not evaluated empirically; rather, its interface and content structure are analyzed from the standpoint of their correspondence to the proposed conceptual model.



Figure 1 – Interface structure of the «Urban Geography» section in the BilimAll mobile application

The analysis of the platform interface shows that BilimAll supports a modular organization of educational content. As presented in Figure 1, the «Urban Geography» section includes several functionally differentiated content blocks, such as textual materials, video resources, practical assignments, web resources, and microblog applications. From a didactic perspective, such a structure is important because it allows the combination of different modes of learning activity within a single digital environment. Textual and video materials support the presentation and explanation of theoretical content, practical assignments facilitate knowledge consolidation and application, while links to web resources and microblog applications create opportunities for extending learning beyond the platform itself.



Figure 2 – Example of a BilimAll lesson interface on contemporary directions of urban development

The platform also demonstrates the possibility of organizing thematic urban content in a visually accessible form. As shown in Figure 2, the lesson devoted to contemporary directions of urban development presents several models of future cities, including the smart city, ecocity, livable city, high-tech city, and biocentric city. In pedagogical terms, such visual structuring makes abstract and multidimensional urban concepts more understandable for school students and helps connect theoretical ideas with recognizable models of urban transformation.

Taken together, these interface and content features indicate that BilimAll can function as a basic organizational environment for integrating urban geography topics into digital instruction. At the same time, the platform's current structure

is most effective when combined with additional digital tools corresponding to the proposed typology, such as web-based GIS, open urban data resources, or citizen science activities. Therefore, BilimAll should be regarded as an illustrative and potentially integrative platform within the broader system of digital tools for teaching innovative urban development in school geography.

The review suggests that the pedagogical value of digital tools in teaching innovative urban development extends beyond the transmission of subject knowledge and is closely related to broader educational outcomes and value orientations. In school geography, urban content is especially suitable for connecting disciplinary learning with sustainability-oriented education, because topics such as smart infrastructure, transport accessibility, green and blue spaces, environmental risk, and public participation are directly linked to the principles of sustainable development [2; 9; 10]. In this respect, digital tools do not simply support visualization or access to information; they create conditions for discussing environmental responsibility, social inclusion, urban safety, and the responsible use of resources through concrete spatial cases.

Another important implication concerns the development of analytical competences. As shown by the reviewed studies, digital tools in geography education support students' ability to work with maps, interpret spatial data, compare territorial patterns, and formulate evidence-based arguments [1; 4–9]. This is especially significant in the context of innovative urban development, where many issues require the interpretation of complex and multi-layered information. Thus, the educational contribution of digital tools lies not only in increasing the accessibility of content, but also in supporting the transition from descriptive learning to analytical and problem-oriented reasoning [1; 2; 8].

The literature also indicates that tasks based on citizen science, collaborative mapping, and open urban data can strengthen the civic dimension of geography education [11–13]. In such learning settings, students are not positioned merely as observers of urban processes, but as participants capable of identifying local issues, interpreting evidence, and reflecting on possible solutions. This is particularly important for the formation of spatial citizenship, because it links geographical knowledge with public dialogue, civic responsibility, and an understanding of the social consequences of spatial decisions [11; 12]. From this perspective, teaching innovative urban development in school geography may contribute to the development of students' readiness to engage responsibly with their local environment and community.

At the same time, the discussion of digital tools in urban education inevitably raises questions of digital ethics. Working with geospatial resources, photographic materials, geolocation-based applications, and public datasets requires attention

to source attribution, copyright, informed consent, responsible sharing of information, and digital safety. Therefore, the pedagogical integration of digital tools should include not only technical and methodological considerations, but also the explicit formation of ethical norms related to the use of digital information in educational settings [11–13].

The findings further show that the pedagogical value of digital tools depends not on the technology itself, but on the quality of its methodological integration into the learning process. Across the reviewed literature, the most productive approaches are inquiry-based learning, project-based learning, case analysis, and problem-based learning [1; 2; 8; 10–12]. In the context of urban geography, these approaches can be organized through a learning cycle that includes identifying a problem, collecting and interpreting data, constructing a spatial representation or model, discussing alternatives, and reflecting on the consequences of different decisions. Such a structure helps transform educational outcomes from simple content acquisition into applied reasoning, informed judgment, and responsible choice.

In relation to the Kazakhstan context, national digital platforms such as BilimAll are important because they provide an institutional and technological basis for organizing digital learning content [19; 20]. From the standpoint of the conceptual model proposed in this study, BilimAll is significant not as a proven instrument of classroom effectiveness, but as an illustrative environment that can accommodate textual materials, video explanations, practical assignments, links to external resources, and communication-oriented elements. This multifunctional structure corresponds to several components of the proposed model and may support the organization of thematic modules related to urban geography.

At the same time, the comparison of BilimAll with the international experience described in the literature suggests that its pedagogical potential for teaching innovative urban development has not yet been fully realized. In particular, the platform could be strengthened through closer integration with school-adapted web GIS tools, open urban data resources, collaborative mapping, and project formats related to local monitoring of environmental or social issues. Such development would make it possible to connect digital content delivery with data-based inquiry, spatial citizenship, and student participation more directly [4–7; 11–13].

An equally important condition for the implementation of the proposed conceptual model is teacher preparedness. The literature consistently shows that the successful use of digital resources in geography education requires not only access to platforms and content, but also methodological support, professional development, and pedagogical guidance [1; 2; 8; 10–12]. For this reason, the adaptation of innovative urban development topics to school geography should be accompanied by short training modules, methodological recommendations,

and exemplars of lesson design for teachers. In the Kazakhstan context, such support could be developed either within platforms like BilimAll or in parallel professional development formats.

Thus, the discussion confirms that the teaching of innovative urban development in school geography should be based on a pedagogically differentiated use of digital tools. Their significance lies in the possibility of combining spatial analysis, sustainability education, civic participation, and digital ethics within a unified educational framework. At the same time, the practical implementation of this approach requires an appropriate methodological infrastructure, alignment with the curriculum, and teacher support. These considerations also indicate that the conceptual model proposed in this article may serve as a foundation for future methodological development and for subsequent empirical studies in school practice.

Conclusion

This article provides a theoretical analysis of international experience in teaching innovative urban development in secondary school geography through the use of digital tools. The review has shown that mobile learning, web-based GIS and web mapping, augmented and virtual reality, educational platforms, citizen science, and public participation tools are increasingly used in geography and sustainability education. At the same time, the analysis indicates that many existing studies focus primarily on individual technologies, whereas the broader pedagogical problem of integrating innovative urban development content into school geography remains insufficiently conceptualized.

The study systematizes the main groups of digital tools relevant to the teaching of urban topics and proposes a typology based on their functional and didactic characteristics. This typology makes it possible to describe the pedagogical role of web-based GIS and online maps, open urban data resources, urban simulation tools, AR/VR-based mobile solutions, and citizen science platforms in revealing such dimensions of innovative urban development as infrastructure, ecology, social inclusion, public participation, and spatial citizenship. From a pedagogical perspective, these tools should be understood not only as means of increasing the visibility of educational material, but also as resources for developing students' spatial thinking, data literacy, critical reflection, informed judgment, and civic responsibility.

Another important result of the study is the development of a conceptual model for integrating digital tools into the teaching of innovative urban development in school geography. The proposed model connects educational goals, thematic content, digital resources, learning activities, and expected outcomes, thereby offering a more coherent framework for lesson design and methodological planning. In this sense, the article contributes to the pedagogical interpretation

of digital urban education at the school level and to the adaptation of international experience to geography teaching.

In relation to the educational context of Kazakhstan, the national platform BilimAll is considered as a potential digital environment for the implementation of the proposed model. Its structure makes it possible to combine textual and video materials, practical tasks, and links to external digital resources within a single educational space. At the same time, the analysis suggests that its pedagogical potential could be further expanded through closer integration with web GIS, open urban data, and participatory digital practices. This creates favorable conditions for adapting the methodological approaches described in international research to the local curriculum and digital educational environment.

Thus, the study provides a pedagogical rationale for the digital transformation of teaching innovative urban development in school geography. Since the article is theoretical in nature, further research may focus on the empirical testing of the proposed typology and conceptual model in school practice.

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ОРТА МЕКТЕПТЕРДЕ ГЕОГРАФИЯ ПӘНІНЕН ҚАЛАЛАРДЫҢ ИННОВАЦИЯЛЫҚ ҚҰРЫЛЫСЫН ОҚЫТУДАҒЫ САНДЫҚ ҚҰРАЛДАР

Бұл мақалада орта мектептерде география пәнінен қалалардың инновациялық құрылысын оқыту үшін сандық құралдарды пайдаланудың халықаралық тәжірибесіне теориялық шолу жасалған. Зерттеудің өзектілігі урбанизацияның өсуімен, «ақылды қала» тұжырымдамасының кеңеюімен, тұрақты даму мақсаттарының маңыздылығының артуымен және қалалық тақырыптарды оқу кезінде оқушылардың кеңістіктік ойлауын, сандық сауаттылығын және азаматтық құзыреттіліктерін дамыту қажеттілігімен анықталады. Зерттеу Scopus, Web of Science, ERIC және Google Scholar базаларында индекстелген Ғылым және білім сипаттамалық басылымдардың құрылымдық шолуына негізделген сипаттамалық және аналитикалық теориялық зерттеу болып табылады. Шолуда қалалық тақырыптарды оқытуда қолданылатын сандық құралдардың негізгі топтары, соның ішінде онлайн карталар мен WebGIS, ашық қалалық деректер ресурстары, қалалық симуляторлар, мобильді AR/VR құралдары, білім беру платформалары және азаматтық ғылым қосымшалары анықталды. Осыған сүйене отырып, мақалада функционалдық және дидактикалық сипаттамаларына негізделген сандық құралдардың типологиясы ұсынылады және мектеп географиясында қалалардың инновациялық құрылысын оқытудың негізгі әдіснамалық қағидаттары тұжырымдалады. Қазақстан жағдайында BilimAll және BilimLand сияқты ұлттық платформалар халықаралық педагогикалық тәжірибені жергілікті оқу бағдарламасына бейімдеу үшін әлеуетті сандық орта болып саналады. Бұл зерттеудің ғылыми жаңалығы қалалардың

инновациялық құрылысын оқытуға арналған цифрлық құралдарды педагогикалық жүйелеуде және оларды мектеп географиясына интеграциялаудың тұжырымдамалық негізін әзірлеуде жатыр.

Кілтті сөздер: мектеп географиясы, қалалардың инновациялық құрылысы, цифрлық құралдар, WebGIS, AR/VR, кеңістіктік азаматтық, BilimAll.

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ЦИФРОВЫЕ ИНСТРУМЕНТЫ В ПРЕПОДАВАНИИ ИННОВАЦИОННОГО ГОРОДСКОГО РАЗВИТИЯ В СРЕДНЕЙ ШКОЛЕ ПО ГЕОГРАФИИ

В данной статье представлен теоретический обзор международного опыта использования цифровых инструментов для преподавания инновационного городского развития в средней школе по географии. Актуальность исследования определяется растущей урбанизацией, расширением концепции «умного города», возрастающей значимостью целей устойчивого развития и необходимостью развития пространственного мышления, цифровой грамотности и гражданских компетенций учащихся при изучении урбанистической тематики. Исследование выполнено в форме описательно-аналитического теоретического исследования, основанного на структурированном обзоре рецензируемых публикаций, индексируемых в Scopus, Web of Science, ERIC и Google Scholar. Обзор позволил выявить основные группы цифровых инструментов, используемых в преподавании урбанистической тематики, включая онлайн-карты и WebGIS, открытые ресурсы городских данных, городские симуляторы, мобильные AR/VR-инструменты, образовательные платформы и приложения

гражданской науки. На этой основе в статье предлагается типология цифровых инструментов по их функциональным и дидактическим характеристикам и формулируются основные методические принципы преподавания инновационного городского развития в школьной географии. В контексте Казахстана национальные платформы, такие как BilimAll и BilimLand, рассматриваются как потенциальные цифровые среды для адаптации международного педагогического опыта к местной учебной программе. Научная новизна исследования заключается в педагогической систематизации цифровых инструментов для обучения инновационному городскому развитию и в разработке концептуальной основы для их интеграции в школьную географию.

Ключевые слова: школьная география, инновационное городское планирование, цифровые инструменты, WebGIS, AR/VR, пространственное гражданство, BilimAll.

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