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Mobile Learning for Sustainable Development and Environmental Teacher Education

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Abstract: Outdoor learning has, for a long time, been an important instructional resource in school education, usually embedded in the natural sciences and social sciences curricula. Teaching geography, geology, or biology beyond the traditional classroom allows students to interact with physical and social environments for meaningful learning. Mobile devices that are based on geospatial technologies have provided more accurate data, but also a combined instructional design with other WebGIS, map viewers, or geographic information system (GIS) layers, which are useful to foster education for sustainable development. This paper analyzes the applications of mobile learning based on citizen science and volunteer geographic information, but also on the growing awareness that citizens and educators need a set of digital competencies to enhance and innovate lifelong learning and active citizenship. The empirical research aims to measure teacher–training experience, highlighting the potential of mobile devices and their applications in environmental education. Data collected from the research and results prove the positive impact of mobile learning in environmental education. Finally, a discussion about mobile learning and education for sustainable development is provided.

Keywords: environmental education; sustainable development; mobile learning; competencies

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1. Mobile Learning for Geographic and Environmental Education

The teaching of school geography has always had an indisputable locational component, which has required leaving the classroom and the school for direct knowledge of the students' natural and social environment. In 1965, the UNESCO Source Book for Geography Teaching established that teaching techniques based on direct observation of geographic space, and in particular fieldwork and outdoor learning, which involve the use of instruments that can be taken out of the classroom and used ubiquitously, were essential to obtain data and check the reality of the terrain. In fact, the teaching of geography has traditionally used "mobile" devices of a nondigital nature such as sketch maps, compasses, topographic maps, photo cameras, atmospheric measuring instruments, etc.

The deployment of digital mobile devices, especially the Global Positioning System (GPS) or even mobile phone GPS apps, has greatly strengthened geographic and environmental education, essentially due to easy access by students and teachers, the ability of these mobile tools to geolocate places and geographic phenomena, and the ability to obtain spatial data can be subsequently processed with a geographic information systems (GIS).

The two main international references in geographic education have highlighted this. The Lucerne Declaration on Geographical Education for Sustainable Development (2007) declared that mobile technologies add specific value to geography education by providing easily accessible, up-to date information, new and innovative means for teaching and learning with web-based information, and enhanced communication and cooperation, for example, in the settings of e-learning and blended learning. For its part, the recent International Charter on Geographical Education (2016) once again pointed out how mobile learning contributes to building on people's own experiences, and helps students to formulate questions, develop their intellectual skills, acquire digital competencies, and respond to issues that affect their lives.

One of the main comprehensive models in education nowadays is the technological, pedagogical, content knowledge (TPACK) model, as it combines instructional design, technologies in education, and disciplinary knowledge [1]. Due to the high development of geospatial technologies, many authors have considered that this model is very useful in geography education [2] in order to develop teaching practices to enable students to think geographically about the complex world from the local to the global scale [3], implement spatial analysis in the classroom, update geography teacher training [4] and teachers' decision making [5], improve learning outcomes [6], raise awareness of the Sustainable Development Goals (SDGs) [7], and, in particular, facilitate geography education with a combined use of mobile devices and GIS [8] and outdoor education [9].

1.1. Technological Approach

Technological approaches for teaching geography have been gaining ground since the first decade of the 21st century, due to the technological innovations and wide spread of mobile devices and mobile apps based on geolocation, which are supported by map viewers and WebGIS. A simple look at the App Store or Google Play confirms that several hundreds of mobile application—including the most popular apps of social media, navigation, outdoor sports, and travel—use location services and information from cell phone carriers, Wi-Fi, Global Positioning System, or Bluetooth to determine the approximate location of the mobile device. Many of them also allow users to record tracking or obtain geospatial information, the data of which can then be processed on desktop computers, particularly in the classroom. This opens to teachers and students infinite possibilities to create their own personal geo-instructional resources, thanks to interactions with the large amount of geospatial technologies: web map and remote sensing viewers (Google Maps, Apple Maps, Here, Bing Maps, Open Street Maps), virtual globes (Google Earth, Nasa World Wind) [10], web-GIS (ArcGIS online), spatial data infrastructure and GIS viewers (Iberpix), digital atlases, etc. In this way, it cannot be doubted that geography is one of the school disciplines that has benefited the most from the recent emergence of new technologies in education, due to geospatial and mobile technologies applied to learning geographical space and knowledge of planet Earth [11,12].

The repertoire of geospatial technologies takes on special importance for mobile learning, since the connection and transfer of information that takes place between mobile devices and digital maps is usually done through the Internet, therefore in the cloud and on software company servers. Hence, the first TPACK model approach, the technological approach, should be based not only on the mobile devices themselves or on software developed ad hoc, such as mobile apps, but also on the link between outdoor/mobile learning and cloud education [13]. New challenges and opportunities are open for the coming years, as the speed [14], capacity, and connectivity will increase with new technologies such as 5G.

The great added value of mobile devices is that they act as modern digital compasses, to which is added the functionality of global positioning (GPS) in latitude, longitude, and altitude, but also in movement and navigation. Some instructional interventions for field trips or treasure hunts have been designed for school students with user-friendly GPS mobile apps and GIS-generated maps [15], and in particular using mobile devices to create GPS exchange format (GPX) files for easy upload to ArcGIS online [16,17], or obtaining data from Collector for ArcGIS [18]. Other proposals have reinforced mobile GIS methods in fieldwork situations where students' work includes the accumulation and evaluation of different types of data to construct a sense of the place they are studying [19]. They suggested that students need to learn how to engage in ways to make meaning of the different layers of history of the research site.

Another important issue is the development of a mobile learning application, and an example is described using map mashups, where students can interact with layers, features, attributes, analysis tools, and other geospatial technologies to learn the lesson concept [20]. Incorporating these mashups as core components of the lessons, and avoiding highly structured exercises, allows greater flexibility and personalization of content.

Last, the technological approach must consider the type of mobile device (GPS, phone, tablet/iPad [21]) and the level of students in primary, secondary, or higher education [22,23], according to the degree of difficulty of the mobile device or app for a more complex analysis and evaluation of the educational benefits of mobile learning [24]. Thus, teenagers and young adults can take advantage of new technologies in mobile learning as QR codes [25], virtual reality [26], augmented reality [27], or 3D visualization [28].

1.2. Pedagogical Approach

A first conceptualization of pedagogical models for mobile learning has been formulated, thanks to the importance of spatial thinking by some researchers [29]. They were concerned with taking e-learning and GIS into the field and exploring the use of mobile and spatially enabled devices and the combination of adventure and media pedagogy with multimedia environmental education. They considered how learning resources and outdoor activities are combined to get original experiences of nature with its varied spatial and temporal dimensions. In spite of the importance of location-based learning and the requirement that students provide more practical examples, the number of days for field visits and practical fieldwork are being reduced, so the model is focused on the key steps for constructive learning: spatial representation and visualization, geo-riddles, and spatial thinking in the field.

Pedagogy for mobile learning with geospatial technologies needs the input of a learning line for the acquisition of spatial competencies [30]. The GI Learner project has defined 10 learning line competencies reflecting an increasing level of complexity, ranging from easy to difficult, for students in secondary education from grades K–7 to K–12. Competency 5 (use GI interfaces) and competency 8 (examine interrelationships) reinforce the role of mobile devices in geospatial learning for some cognitive tasks on spatial thinking such as applying (finding locations, measuring distances, comparing routes, looking for facilities) and analyzing (recognizing spatial relationships or spatial changes).

The integration of inquiry-based learning and field trips is another issue analyzed by several authors [31,32]. Exploring the terrain [33] can allow students the opportunity to ask geographic questions, acquire geographic resources, visualize geodata in the field, process data, and answer the questions. Thus, mobile learning on field trips facilitates the instructional sequence of observation–comprehension–analysis–interpretation, as the students make sense of the data, so learning places become meaningful, and the learning process is more experiential [34] and collaborative. Participatory GIS models [35] and field trips as lessons plans [36] also contribute to this approach.

Mobile learning is also used in higher education, in particular in undergraduate geography courses. The educational use of mobile devices needs to define a series of instructional objectives in order to be purposeful. IPAC is a methodological approach to assessing mobile technologies and field-based learning, but also a pedagogical framework to evaluate or measure how college students are using mobile technologies for their learning [37,38]. It comprises eight pathway questions, which indicate a clear structured activity for effective use of mobile learning technology. In other words, mobile learning must contribute to personalized and ubiquitous learning using affordable (bring-your-own-device) and user-friendly devices and software, increasing experiential learning and social networking, as well as a rational instructional design to increase student engagement with the curriculum and facilitate autonomous learning [39]. In addition, mobile-learning pedagogy requires specific assessments, different from assessments for traditional classroom, for teachers to check if students have learned what was expected of them [40].

The European Association of Geographers (EUROGEO) has published a book in which mobile learning also plays an important role in informal education contexts. For example, YouthMetre and Geocitizen are interesting experiences of mobile learning to increase youth participation and active engagement with civic proposals [41], and other contributions indicate the advantages of the problem-based learning approach in mobile learning [42] or the neogeography aspect of collaborative learning and geospatial communication [43]. One way or another, a pedagogy for mobile learning must be conceived for formal education at any level, but also for lifelong learning [44] and teacher training [45,46], as UNESCO has recommended [47].

1.3. Geographical Content Approach

Learning about geographic space is extensive due to its diversity and complexity, but above all the breadth of the curriculum. It includes content on spatial thinking, physical geography, human and economic geography, and regional geography, but in particular, interactions between the physical and human environment, changes in places, spaces, and landscapes, and the challenges of sustainability. This structure, with some variation in relation to geographic competencies or the use of geospatial technologies, is the one that is repeated in most national geography curricula in primary and secondary education across European countries [48]. In this way, using mobile devices, especially in fieldwork and outdoor learning, becomes a very valuable way to teach geography from the direct perception, understanding, and analysis of those geographical phenomena and processes at the local and regional scale that are more abstract at the national or global scale, and are better understood when they are taught in classrooms.

For this particular research, we focused on environmental issues and landscapes, as described in the Methodology and Results sections. There are several contributions describing successful experiences to acquire content for the geography discipline, but also to raise environmental awareness, such as EarthCaching [49], based on geocaching, in which users self-report beneficial environmental behavior like saving energy or shopping and commuting in an environmentally friendly manner. Landscape and environmental challenges are undoubtedly the two more important topics in mobile learning in geography, because of their high potential for learning landscape features and reconstructions [50] and the possibilities given by mobile devices for surveying impacts on both the natural and built environment [51].

1.4. From Geographic Competencies to Field-Based Citizen Science

Mobile learning contributes decisively to student's acquisition of geographic competencies based on effective geospatial technologies: spatial thinking, geographical knowledge, and spatial citizenship [52]. Some references have been provided for the first two; spatial citizenship is an essential competency to develop critical thinking and educate citizens on proposing actions to improve their everyday environment [53]. The practical applications of geospatial technologies embedded in mobile-learning practices (for example, traffic and transportation, smart-city approaches, environment, social media, etc.) contribute to daily personal decisions toward developing a more sustainable planet. Spatially informed students, as future citizens, better understand the interactions between the local impacts and global challenges (like climate change) that contribute to global understanding in geography education [54].

Spatial citizenship principles for developing critical thinking include using geospatial technologies, reflecting on data provided by geomedia, and actively communicating and participating through social media or apps using geolocation. One app for mobile devices is ArcGIS Survey 123 [55], useful for field data collection, as well as for developing a field-based citizen science mapping of many topics, as people can express their geo-located opinions about trees and shrubs, animal species, weather, water quality, soil chemistry, cultural heritage, noise level, pedestrian paths, traffic, neighborhood changes, urban facilities, or any other phenomenon.

2. Materials and Methods

The main motivation for the research of this paper is to verify whether primary school teachers acquire digital competencies in their initial teacher training and undergraduate programs through mobile learning. If so, what is the degree of digital competencies acquired? What are the curriculum components and cognitive processes that are more correlated to digital competencies? In addition, can mobile learning and environmental teacher education contribute to raising awareness of the SDGs? Thus, teachers will be able to use mobile learning with their pupils in order to promote geographic education for sustainable development, and in particular, for sustainable landscapes and environment.

2.1. Digital Competencies

In teacher education, professional competencies depend on subject-specific knowledge and skills in specific pedagogical domains. The competencies serve as a basis for the implementation of an educational approach to the practice of teaching and learning and are strongly related to curriculum development. Digital competencies are part of the key transversal competency that citizens increasingly need to acquire. They are considered to be necessary in order to achieve a degree of literacy suited to the present-day needs of society. DigComp is the European Commission's methodological framework designed to support an understanding of digital competency for European citizens. It includes issues such as information storage, digital identity, and developing digital content and behavior online and in everyday life such as working, shopping, and participating in society. The current research is based on the methodology of the EC DigComp framework, as it provides a capacity-building tool through the identification of flaws and possible opportunities for improvement in schools, in order to overcome the digital data skills gap. An important part of our research was based on evaluating teachers' digital competencies according to the areas identified by DigComp 2.1 [56]. This is the latest version (2017) of a comprehensive framework developed by the European Commission in 2013 and later endorsed by the European Union Digital Education Action Plan (2018), which also highlights the role of mobile learning in digital education.

The purpose is to provide a common reference tool regarding digital competencies in Europe. The initial document of the Digital Competence Framework for European Citizens (DigComp 1.0.) was based on 5 areas of digital competency: information and data literacy, communication and collaboration, digital content creation, safety, and problem solving. DigComp 2.0 presented a list of 21 competency descriptors and titles that are pertinent to each of the 5 areas. Finally, DigComp 2.1 expanded this model further by adding 8 proficiency levels and examples of use, applying a methodological approach of learning progression that is quite similar to the model used by geography educators in international research [57].

Since DigComp 2.1 provides a detailed methodological framework, it was chosen for the analysis of teacher education in primary school curricula, focusing on digital topics in terms of prescribed competencies and levels that can be achieved by undergraduate students. The levels go from level 1 (foundation) to level 8 (highly specialized). For this research, we did not consider levels 7 and 8, for 2 reasons: mobile learning in DigComp 2.1. is mostly focused on levels 1 to 6, and levels 7 and 8 are conceived for European citizens who have acquired a professional or adult level of competence, which is impossible to replicate for teachers in primary education with children 6 to 12 years old, or for teachers in secondary education. The levels retained for this research are described in Table 1.

Table 1. Proficiency levels 1 to 6 in DigComp 2.1.

Level	Complexity of Tasks	Autonomy	Cognitive Domain
1	Simple tasks	With guidance	Remembering
2	Simple tasks	Autonomy and with guidance where needed	Remembering
3	Well-defined and routine tasks and straightforward problems	On one's own	Understanding
4	Tasks and well-defined and non-routine problems	Independent and according to one's needs	Understanding
5	Different tasks and problems	Guiding others	Applying
6	Most appropriate tasks	Able to adapt with others in a complex context	Evaluating

At the same time as DigComp 2.1 (2017), the European Commission published another European Framework for the Digital Competence of Educators (DigCompEdu) [58]. In total, 6 digital competencies were defined to equip teachers to fully exploit the potential of digital technologies to enhance teaching and learning, including mobile learning, and adequately prepare their students for living and working in a digital society. The 6 competencies were professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence. This report has also a strong methodological focus, as each competency was based on a progression model by describing 6 stages or levels of digital competency development: newcomer, explorer, integrator, expert, leader, and pioneer. This reinforced our methodology for this research, even though it was focused just on teacher training, which belongs to the first topic of professional engagement. This study should eventually be followed by another one in the future to measure the evidence of teachers, as professional primary educators in classrooms, with mobile learning to assess the levels attained according to DigCompEdu.

Finally, another pedagogical variable was introduced into the research methodology to find out the correlation with the 6 levels described: curricular competencies. Teacher training in geographic education is strongly conditioned by the national curriculum, and in this case by the guidelines for national curricula in European countries given by the European Framework on Key Competencies for Lifelong Learning [59]. This report (published in 2006, updated in 2018) defined 8 key competencies for lifelong learning; the third one, competence in mathematics, science, technology, and engineering, involves learning about the natural world, the environment, and sustainability. At the same time, this competency includes a combination of knowledge, skills, and attitudes. Thus, the second variable for our study consisted of 3 dimensions of mobile learning for setting the geography curriculum for scientific competence, but also Sustainable Development Goals from a geographical and environmental approach [60,61]: knowledge of the environmental discipline (climate, water, biodiversity, energy, waste management, built environment); skills for obtaining, processing and presenting geospatial data through mobile devices; and raising awareness of Sustainable Development Goals, in particular 6, 7, and 11–15.

2.2. Participants and Instruments of Research

The research was carried out by analyzing the documentation of 188 academic works as a result of training teacher workshops for primary education at the University of Zaragoza, Spain. Each of these works, used to assess and grade students, was carried out collaboratively by a group of 3 students in the bachelor's degree program in primary education, in the geography education course, over the last 8 years. As this course is placed in the second year of the syllabus, almost all students are between 19 and 20 years old; about 70% are women.

All of this material allowed us to observe the evolution and variability of the statistical sample, in the acquisition of both the 6 digital competencies formulated by EduComp.2.1, and of knowledge, skills, and attitudes of scientific competence. Workshops consisted of two types of activities, face-to-face sessions and field trips to collect data with mobile devices, preferably mobile phones, as they have both GPS functions and cameras (Figure 1). Students were allowed to use any GPS software, but particularly those that had a high level of location accuracy (Oruxmaps, MotionX-GPS, Wikiloc, IGN, etc.) and were user-friendly to create GPS exchange format (GPX) files and/or KMZ files to be uploaded later to an online GIS platform (like ArcGIS), a map viewer (like Google Maps), a virtual globe (like Google Earth), or an SDI (like Iberpix), or just to create StoryMaps (Figure 2).

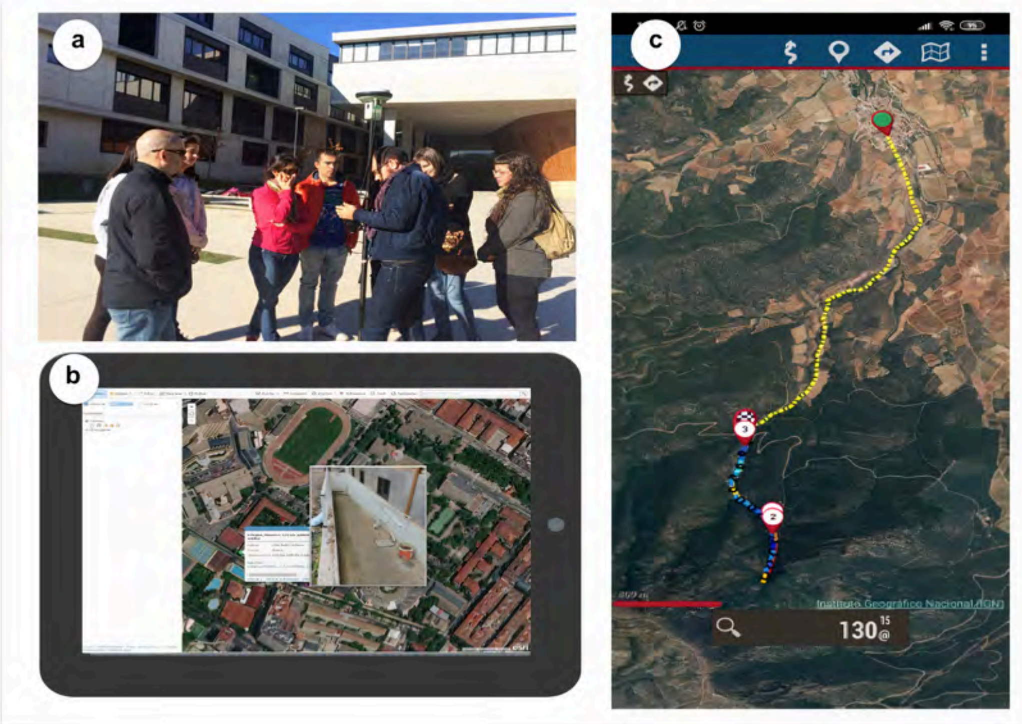

Figure 1. Fieldwork data collection with different devices: (**a**) data collection with GPS in front of a college building; (**b**) analysis by collecting geographic and graphic information with ArcGIS Collector of mobility adaptation on the San Francisco campus; (**c**) route of educational itinerary in Sierra del Algairén (Aragón, Spain); itinerary taken with IGN Maps of Spain.

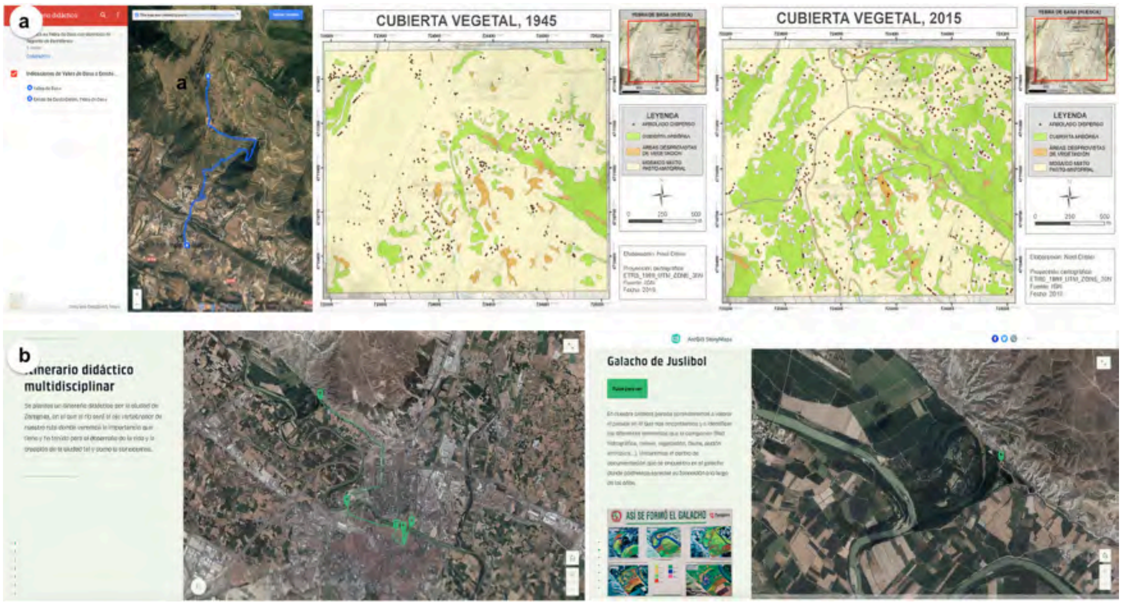

Figure 2. Instructional approach for obtained information: (**a**) educational itinerary in which landscape analyses from 1945 to 2015 are compared with software used in Google Earth and ArcMap; (**b**) fluvial route along the Ebro River; a StoryMap was made to explain the river course, river bank evolution, and landscape diversity to students, so they can appreciate the environmental changes and impacts.

3. Results

The 188 works were evaluated according to their content and the acquisition of competencies in: (i) obtaining, processing, and presenting geospatial data; (ii) having knowledge of the environmental discipline; and (iii) raising awareness of the Sustainable Development Goals. These competencies were evaluated following the model proposed by DigComp on six levels, as mentioned above. In order to check whether there are significant differences in the degree of acquisition of competencies due to the pedagogical methodology, a statistical analysis of the sample was carried out with SPSS software. The descriptive statistics of the data were calculated, the normality of the sample and the homogeneity of variance were verified, and finally ANOVA was carried out.

3.1. Descriptive Statistics

We observe in Table 2 that the sample of ordinals lacks extreme values to a certain extent; that is, students acquire a medium level of competency. It is clear in general terms that students are able to perform routine tasks, solve simple problems, and understand environmental challenges autonomously. However, we cannot conclude with absolute certainty that the differences observed are due to the effect of the applied pedagogical methodology or they are the product of the inherent variability of the samples; that is, if students acquire higher levels of competency in some topics than others.

Table 2. Summary of variables used in the analysis.

	Obtaining, Processing, and Presenting Geospatial Data	Having Knowledge of Environmental Discipline	Raising Awareness of Sustainable Development Goals (SDGs)
Mean	3.9167	3.8750	3.9167
Median	3.0000	3.0000	4.0000
St. Deviation	3.93475	4.08227	3.37597

In order to test this hypothesis, we calculated normality with the Shapiro–Wilk test (Table 3). All *p*-values (statistical significance) are greater than the 0.05 significance level. So, the samples of the concentrations are distributed in a normal way in each of the three competencies analyzed.

Table 3. Normality test.

	Notes	Statistic	al	Significance
Obtaining, processing, and presenting geospatial data	1.00		8	
	2.00	0.877	8	0.178
	3.00	0.866	8	0.138
	4.00	0.939	8	0.603
	5.00	0.815	8	0.041
	6.00	0.848	8	0.090
Having knowledge of environmental discipline	1.00		8	
	1.00		8	
	2.00	0.899	8	0.283
	3.00	0.963	8	0.836
	4.00	0.938	8	0.593
	5.00	0.895	8	0.261
	6.00	0.894	8	0.255
Raising awareness of SDGs	1.00		8	
	1.00		8	
	2.00	0.851	8	0.097
	3.00	0.972	8	0.916
	4.00	0.866	8	0.139
	5.00	0.932	8	0.534
	6.00	0.753	8	0.009

3.2. Analysis of Variance

Once we established that our sample was normally distributed and independent and maintained the homoscedasticity principle, we calculated the factorial ANOVA model. As can be seen in Table 4, the *p*-value is extraordinarily small, which leads us to reject the null hypothesis and therefore accept the alternative: there is more than enough statistical evidence to conclude that the adopted pedagogy and instructional methodology has an influence on the level of acquisition of the three competencies described above.

Table 4. ANOVA.

		TSS	gl	RMS	F	Significance
Obtaining, processing, and presenting geospatial data	Between groups	462,167	5	92,433	14,622	0.000
	Within groups	265,500	42	6321		
	Total	727,667	47			
Having knowledge of environmental discipline	Between groups	449,500	5	89,900	11,313	0.000
	Within groups	333,750	42	7946		
	Total	783,250	47			
Raising awareness of SDGs	Between groups	361,667	5	72,333	17,460	0.000
	Within groups	174,000	42	4143		
	Total	535,667	47			

Finally, multiple comparisons with the Bonferroni method show *p*-value < 0.05 in the first two groups for scores above 3. The *p*-values for the case of SGDs stand out. In fact, it seems that the mean of the score of raising awareness of SDGs is significantly higher than that of obtaining, processing, and presenting geospatial data or having knowledge of environmental discipline, since it obtains the highest significance values: level 4 = 0.002; level 5 = 0.024; and level 6 = 0.031.

4. Discussion, Limitations, and Conclusions

The first conclusion from this research is the growing importance of digital skills in teacher training, so that teachers can carry out their professional activity in such a way that their pupils, in turn, will acquire the digital skills indicated in the Digital Competence Framework for European Citizens. To achieve this, it is essential that teachers are proficient in the use and educational management of innovative hardware and software, including mobile devices.

A complementary conclusion is that mobile devices have a very effective function when it comes to outdoor learning, particularly in curricular content related to the landscape, the environment, or sustainable development, which is usually linked to geography classes in primary and secondary education. In this sense, mobile learning contributes not only to education for sustainable development or spatial citizenship, but to the fostering of sustainable citizenship, enabling students to develop sustainable attitudes so that they can take a critical view of the environment [62] or any topic related to the Sustainable Development Goals.

Due to the powerful quantitative and qualitative geospatial information provided by mobile learning, teachers should take advantage of it for more meaningful education about the natural and built environment. Mobile learning allows the creation of personal and adapted geo-information based on locations, places, and spaces well known by students in primary and secondary education, so they can later reuse this information in map viewers and Web-GIS to implement inquiry-based learning. Thus, students can raise their awareness of environmental and sustainable challenges like climate change, the impact on rivers and forests, and waste management, because they know, recognize, and belong to places where they live and have previously visited.

More precisely, this research has made it possible to confirm the hypothesis that mobile learning facilitates the acquisition of digital competencies in teacher training at medium-high levels, with an average score of four (from one to six). This means that most young teachers have reached an advanced level of task complexity (equivalent to the expert level in DigCompEdu), which allows them to teach with enough confidence in their digital competency, so that they can facilitate problem solving in the classroom. The fact that mobile learning and fieldwork have been used to explain particular environmental issues to students makes it easier to understand generic or abstract concepts: recording a track in a derelict landscape, creating a path close to a flooded river that has a tremendous impact on urban settlements, or measuring the surface of a deforested area (as seen in Figures 1 and 2) can contribute to a better understanding of the Sustainable Development Goals and raise awareness of global sustainability. Significance scores obtained in the SGD competences are slightly higher than the other two categories (processing data, having knowledge), so results prove the validity of the hypothesis.

Democratizing the use of open data in sustainable development education, and in particular in fieldwork for environmental learning, empowers students to make sustainable decisions for places and spaces. Students are motivated when they learn directly from local environment, but also, they implement a more accurate spatial as they combine in-situ observation of geographic phenomenon with Web-GIS tools. Thus, fieldwork improves data collection, spatial analysis, interpretation of geographical distributions, critical–systemic thinking, and promoting actions for change. The more the environment is known, the more it is valued and therefore the better it is protected.

We also found that a long-time sample of students does not affect the digital gap. In other words, higher or lower scores are due to the involvement of undergraduate students. We did not find higher scores for final-year students in the sample. This may be due to the fact that the analyzed students can all be categorized within the first digital generation with average knowledge about the use of the Internet and communication technologies.

A limitation of this research is that it focused only on teacher training, and not on real professional teaching activities with primary students. A further study will allow us to enlarge the results of this study, but also to check how mobile learning is embedded into educators' competencies beyond professional engagement or the use of digital resources, such as through student learning outcomes or empowering learners.

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