Chapter 8
Fossils, Smartphones, Geodiversity, Internet, and Outdoor Activities: A Technological Geoeducational Bundle

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8.1 Introduction: We Live in an Urban and Technological World

Now that we are halfway into the second decade of the twenty-first century, saying that technology is all around us has become a bit of a cliché. The use of technological gadgets in everyday life is no longer science fiction wishful thinking; it is a "fait accompli," a done deal.

It is not the purpose of this work to accurately define the nature of the world we currently live in. Therefore, it is probably an exaggeration – a figure of speech if you will – rooted on the biased perception we have of the so-called Western world, to state that today's life is defined or even governed by technology. Nevertheless, it is at least reasonable to say that we live in a world that is deeply influenced by it.

On the other hand, it is not a hyperbole to state that we – at least from a strictly demographic point of view – already live in an urban world. According to United Nations data, the urban population of the planet has grown swiftly since 1950, from 746 million to 3.9 billion in 2014. Today, globally, more people live in urban areas than in the countryside, with 54 % of the world's population (United Nations 2014), and although world asymmetries are gigantic, the population living in cities presently generates in excess of 80 % of global GNP.

Therefore, with the majority of people living in metropolitan areas, there is a strong case for using urban geodiversity, rocks, fossils, landforms, etc., in outdoor geological educational and geoawareness activities (e.g., Prosser and Larwood 1994; Zinko 1994; Doyle and Bennett 1998; Silva and Cachão 1998; MacFadyen and McMillan 2002; Gray 2004; Silva 2009a, b; Ventura et al. 2010; Mayoral et al.

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C. Vasconcelos (ed.), *Geoscience Education*, DOI 10.1007/978-3-319-43319-6_8

2012; Rodrigues and Agostinho 2016). This does not mean – not by a long shot! – that field activities, in natural settings, should be discarded or even neglected.

Furthermore, a large portion of the world's population has access to basic technological tools and resources that would seem utterly futuristic just some 35 years ago. According to the Ericsson Mobility Report (2015), in 2014 there were 2600 million smartphone subscriptions worldwide, and forecasts predict that by 2020 advanced mobile technology will be globally ubiquitous with 70 % of people using smartphones. The use of laptops, computer tablets, Internet access, and GPS-capable devices of various kinds is commonplace these days, especially so when it comes to the younger generations. Despite the fact that today, as a result of plummeting fertility rates and longer life expectancy, the share of global population under age 20 has fallen to 35 % – from 48 % in 1970 (Population Reference Bureau 2014) – still an important slice of the planet's population was born and grew up in a world with personal computers, cell phones, GPS, and Internet. For an important portion of these youngsters, these are not technological novelties, but everyday commodities that they take for granted.

Therefore, why not combine the two facts described above – mostly urban population with access to technology – and use them in outdoor geoeducational and geoawareness activities in urban areas and also in natural environments? The hardware (smartphones, computers, GPS devices) and the software associated to it (mobile apps, web application hybrids – mash-ups – such as Panoramio and Flickr, and digital publishing platforms the likes of Issuu, etc.) are increasingly accessible in urban areas around the world, and even in rural ones, and may be used successfully to create synergies capable of supporting such activities.

In this work, a series of activities and experiments in geoeducation and geoawareness actions using commonly available technology, set both in urban and natural environments, will be presented and briefly discussed. These activities have been tested and used in middle school, high school, and university teaching and in science popularization activities for the broader public fostered, mainly, by undergraduate (Bottino et al. 2014) and graduate students (Ventura et al. 2010) and teachers and researchers (e.g., Silva and Cachão 1998; Silva 2007, 2009a, b) of the Department of Geology of the Faculty of Sciences, University of Lisbon (Portugal).

8.2 QR Codes, Cobbled Pavements, and Urban Geodiversity

A Quick Response code, commonly designated by the acronym "QR code," is a special type of two-dimensional bar code installed to provide easy access to information through the use of special software in a decoding equipment, more often a mobile application (an app) designed to run on mobile devices such as smartphones and tablet computers equipped with cameras (Shin et al. 2012). The process of reading the code, known as mobile tagging, commonly works as follows: after opening the QR code reader app which works in association with the device's camera, the user points it to the code; the app interprets the code, which typically triggers a call to action such as an invitation to download an app, a link to view a specific webpage or a video, etc.

Today, these QR codes are very widespread in urban environments – both indoors and outdoors – and may be found in a variety of situations, ranging from ads in publications to consumer products (breakfast cereal and beverages, cosmetics, etc.), publicity outdoors, public transportation sites, museum exhibits, etc.

8.2.1 Traditional Stone Pavements and QR Codes

The tradition of using artistic cobbled pavements in pedestrian areas in Lisbon, locally known as "calçada portuguesa artística" or artistic Portuguese pavement, is long and widespread (Fig. 8.1). The stone artisan that lays the pavement is known as the "calceteiro." White compact Jurassic limestone is used in conjunction with Jurassic black compact limestone and/or Cretaceous basalt to produce an impressive set of geometric pavement patterns and pavement pictures. It is a very vibrant and artistic fusion of geological resources – the limestone used is quarried in the Calcareous Massif of Estremadura, some 100 km north of Lisbon – and cultural

Fig. 8.1 Rosette and loop patterns in the pavement of the Duque da Terceira Square in downtown Lisbon; two examples of the many different patterns used in the typical artistic Portuguese pavement. White cobblestones, compact, fine-grained Jurassic limestone; black cobblestones, Cretaceous basalt and/or compact, fine-grained black Jurassic limestone. Average dimension of the cobblestones, circa 4–5 cm across. Note the star in the center of the rosette; it is the signature of the "mestre calceteiro," the master artisan that laid that stretch of pavement

traditions in urban areas. This type of pavement is also used in other urban areas of the country but, usually, not as elaborately nor as extensively as in Lisbon. Gray (2004) mentions these pavements in Lisbon and Funchal (Portugal) when discussing the economic value of geodiversity (building materials), but they could also be seen as examples of the aesthetical value of geodiversity in urban areas.

Using the slogan "Reprogramming the City: Unlocking the Potential of Existing Urban Assets," the QR Chiado initiative developed by Lisbon-based creative agency MSTF Partners produced a series of cobbled QR codes fusing the tradition of Portuguese artistic pavements and new technologies (see QR Chiado 2015 in the References; "Chiado" is a popular barrio in downtown Lisbon; Fig. 8.2).

Using a biological metaphor, one could even say that the Portuguese pavement was "preadapted" for QR codes since it is made of black and white typically square-shaped cobblestones. Therefore, QR codes made of compact, fine-grained, black and white Jurassic limestone cobblestones were built-in in the Portuguese pavement of Lisbon for pedestrians to obtain information about historical landmarks or local history or any other useful information. Just as the building stone of Lisbon used to tell coded tales of seafaring sagas, geographical discoveries, and foreign cultures, the very same stones were now recoded to convey present-day tales and information via mobile digital devices (QR Chiado 2015).

Fig. 8.2 QR codes made of compact, fine-grained, black and white Jurassic limestone cobblestones built-in in the Portuguese pavement of Lisbon for pedestrians to obtain information about historical landmarks or local history and useful city information. White cobblestones, compact, fine-grained Jurassic limestone; black stones: compact, fine-grained black Jurassic limestone. Average dimension of the cobblestones, circa 4–5 cm across

In the same way that street designs and paving techniques were exported from Portugal to other countries around the world – France, Brazil, Catalonia (Esparza-Lozano 2014), China (Macao), Mozambique, East Timor, etc. – during the twentieth century, QR Chiado has been exported to Rio de Janeiro and Barcelona to be used in their city's paved surfaces.

The paved QR codes – using Portuguese pavement techniques or local traditions – may very well be used to convey information about the very same geological materials they are made of. Ornamental rocks, fossils, landforms, and landscapes seen in the city could be successfully deciphered using these codes, both in educational activities and in geoawareness ones.

8.2.2 Geodiversity, Fossils, and QR Codes

In a related experiment, using QR codes to decode geodiversity aspects, mainly fossils, Bottino et al. (2014) developed a series of codes to be posted in popular city locations associated with obvious fossil occurrences and designed to open a webpage with basic information about them (Fig. 8.3). QR codes have been introduced

Fig. 8.3 Fossils and QR codes in downtown Lisbon. In an activity conducted by Bottino et al. (2014), several QR codes where strategically placed next to urban fossil occurrences in popular city locations. On top of the QR code, a short caption reads: "Que fóssil é este?" (What fossil is this?). In this case, a few fossilized specimens of coiled caprinid rudist bivalves are visible. These fossils are common in Upper Cretaceous limestone occurring in the Lisbon region. Note the Portuguese pavement pattern on the sidewalk

into field trips before, namely, for biology classes (the "scan and learn" teaching method of Lee et al. 2011), but in those cases, the codes were used in previously prepared QR code sheets that the students took with them into the field trip, instead of a traditional illustrated guidebook to the natural fauna.

For this activity, the webpages and the QR codes were developed having in mind rudist bivalve fossil occurrences (Fig. 8.4). The Rudista are an extinct molluskan bivalve group. They arose in Late Jurassic, became very diverse during the Cretaceous, and died out by the end of the Mesozoic Era (in the end of the Cretaceous). Rudists lived in tropical shallow marine environments bordering the Tethys Sea. This tropical sea existed during much of the Mesozoic Era, before the opening of the Indian and the Atlantic Oceans in the end of the era, during the Cretaceous Period. The Tethys had a general East-West distribution, separating the northern Laurasia supercontinent from the southern Gondwana. Rudist fossils – both radiolitid and caprinid rudists – are very common in the "liós" limestone quarried some 25 km NW of Lisbon, in the Sintra region. The "liós" – a stone industry designation – is a high-quality construction and ornamental stone widely used both in historical and contemporaneous buildings all over the city, but especially in downtown Lisbon.

The QR codes used in this activity were generated for free using open-access software available in websites such as "QR Code Generator" (http://goqr.me). Several other open-access generators are readily available online. The procedure is straightforward. After creating and uploading the webpage with the required

Fig. 8.4 Example of a test webpage linked to a QR code placed in loco next to the urban fossil occurrences and designed to provide compact and easy to understand information for the nonspecialist about urban fossils – Cretaceous caprinid rudists – in Lisbon (Adapted from Bottino et al. 2014)

information (e.g., Fig. 8.4), enter the webpage's URL in the online code generator, and the QR code will be created automatically as you type. The code may then be downloaded, printed, and used as many times and in as many locations as needed. Test the URL by scanning the code with a QR reader app and you are ready to go! For further information on how to create QR codes, refer to Lee et al. (2011).

8.2.3 QR Codes and Urban Geodiversity Go Both Ways

The above-described geodiversity activities using QR codes may be approached from both ends:

(a) From the "final end," working QR codes already in place may be used as beacons to steer urban field trips (guided or autonomous), to serve as meeting points or "treasures" to be discovered in urban "scavenger hunts," or – if used autonomously – to alert the general public to geodiversity occurrences in the city, thus promoting geoawareness and, hopefully, leading to geoconservation of urban and natural geodiversity.
(b) From the "starting end," the activity could consist in the selection of urban aspects that one wished to share and make available for the intended target audience (middle and high school students, the general public, etc.) and then create the necessary webpages (selecting relevant information, obtaining the images, designing the webpage) and generate working QR codes.

Furthermore, since most schools incorporate in their buildings some kind of ornamental stone, often fossiliferous – e.g., liós limestone and rudist fossils are a common feature in Portuguese schools in Lisbon and elsewhere – QR codes may also be used inside the school itself in order to promote responsible and acceptable use of smartphones during school social time, as suggested by Welsh and France (2012).

8.3 Websites, Urban Trails, and Geodiversity

The fact that the majority of people are now living in city environments offers an excellent opportunity for using urban geodiversity elements – landforms, rocks, fossils, etc. – in outdoor geological educational and geoawareness activities (e.g., Silva and Cachão 1998; Gray 2004; Silva 2009a, b; Ventura et al. 2010; Parra et al. 2012; Mayoral et al. 2012; Rodrigues and Agostinho 2016).

A traditional Portuguese proverb states that "If the mountain will not come to Mahomet, Mahomet will have to go to the mountain." The expression means, of course, that if one cannot get one's own way, one must bow to the inevitable. In this geological context, it could also mean that the world – especially the natural world – should not be treated in a cavalier way, but respectfully. When it comes to geoawareness urban trails, the rationale behind them could metaphorically be stated as follows: “If Mahomet will not go to the mountain, then we will bring the mountain to Mahomet”; if the typical contemporaneous urban dweller – student or not – is reluctant to leave the city and visit natural geological occurrences, then we will show him the geology that may be seen, everywhere, in the city (Silva 2009a).

The vast majority of materials used in urban constructions, from the stone used in the pavements to the tiles in the roofs, including the building and the ornamental stones used in edifices, just to mention a few, are geological in nature. The city of Lisbon is no exception. Several interesting paleontological aspects may be observed there: e.g., somatofossils (body fossils) of Jurassic belemnites, Cretaceous rudist bivalves and Miocene gastropods, as well as ichnofossils (trace fossils), burrows of Cretaceous, and Miocene crustaceans, abound. The observation and interpretation of geological and paleontological aspects that do not simply occur in the city but are also part of it, merging together in its urban structures forming the very fabric of the city, makes it easier for students and the general public alike to appreciate the importance of geology and geodiversity and understand its intimate connection with the local culture and everyday urban life (Silva 2009a, b).

8.3.1 Websites and the “Fossils Just Around the Corner” Trails

City people, young and old alike, are typically sedentary, highly dependent on their urban environment, and easily lose touch with the natural world beyond city limits. Hence, urban pedestrian trails aimed at the observation of paleontological and geological aspects are paramount for promoting public awareness about geological issues and about the values of geodiversity. The “fossils just around the corner” walking trails in downtown Lisbon organized by the Department of Geology of the Faculty of Sciences of the Lisbon University is a perfect example of this. These city tours started in 1998 (Silva and Cachão 1998; Silva 2009a) and continued to be held to the present time under the auspices of the “Geologia no Verão” (Geology in the summer) initiative of the “Agência Ciência Viva” (Live Science Agency), the Portuguese Agency for Scientific and Technological Culture.

The trail may be guided by trained geologists – typically postgraduation students from the geological department – or walked autonomously. For those who wish to walk independently, a straightforward informative webpage was created. It features the main aspects to be seen along the trail and provides a leaflet – downloadable in pdf format – with a map of the trail and basic information about what may be seen in it [see Silva (2011a) for the webpage and Silva (2011b) for the leaflet]. Since 1998, approximately 200 guided visits have been organized, for middle and high school students, teachers, geological congresses, and the general public. In these 18 years since the inception of the “fossils just around the corner” experience, we estimate that more than 2500 people participated in the guided visits alone, some of them more than once.

The Lisbon "fossils just around the corner" successful experience was replicated in other Portuguese cities and also in Spain, namely, in Almada (Portugal) and Huelva (Spain). For these cities, the autonomous trail option was privileged, and, therefore, more elaborate and informative websites were created to support it.

Almada is a satellite town of Lisbon, situated south of the capital, straight across the river Tagus. The "Fósseis na cidade" (Fossils in the city) trail was especially designed to show that even in suburban, mostly dormitory towns such as Almada, it is possible to find interesting and challenging urban geological and paleontological elements that may be easily used in educational activities related, e.g., to the middle and high school curricula, namely, the themes "sedimentary rocks" and "fossils and fossilization." Seven urban geospots where identified in the Capitão Leitão street of Almada (Fig. 8.5), the main street of the town's older quarters. The geospots are mostly related to the occurrence of fossils (Jurassic corals, Cretaceous caprinid and

Fig. 8.5 General composite aspect of the homepage of the "Fossils in the city" website of Almada (Portugal). The homepage provides general information on the rationale of the activity and general information on the location of the selected urban geospots and what may be seen in each one of them. A map provides links and a visual index for the geospots tagged along the urban trail (See Silva 2007)

radiolitid rudists, Jurassic and Cretaceous gastropods, Cretaceous bivalves) in ornamental stone, but one of them is devoted to the topic "Threats to Geodiversity." This latter spot is focused on the negative impact that urban mismanagement, pervading publicity, and extensive graffiti may have not only on the urban environment, in general, but also on its geological and paleontological aspects. Further information about the Portuguese Almada "Fósseis na cidade" (Fossils in the city) activity and website and its Spanish Huelva counterpart "Fósiles en la ciudad" (idem) may be found in Silva (2007) and Ventura et al. (2010), for Almada, and Mayoral et al. (2011, 2012, 2013) and Parra et al. (2012), for Huelva.

Since these trails herein described and discussed are set in urban areas, a simple street address is sufficient for the autonomous trailgoers to find the selected urban geospots. Nevertheless, GPS coordinates may successfully be provided in websites in the form of downloadable files intended to be installed and used in commonly available GPS-capable devices, namely, smartphones and tablets.

8.3.2 Geodiversity in the Campus of the Faculty of Sciences, Lisbon

Involving people in geodiversity is paramount, and the manner geotopics are presented to the public is crucial to the way geodiversity is perceived and valued (Larwood and Durham 2005). There are many ways of involving people in these activities, probably, as many as there are different people. A way of involving young people is, for instance, using innovative updated means of communication. Books, leaflets, and brochures are no longer appealing to the average youngster. On the other hand, information conveyed in websites and social networks, accessible using computers and mobile devices, is. A recent internal survey held by the Faculty of Sciences of the Lisbon University showed that one of the three main factors attracting students to the faculty was the usefulness and attractiveness of the faculty's website, the other two being the prestige of the institution (mostly based on their parents' opinions) and having participated in educational and science popularization activities in the faculty – promoted by the faculty – during their high school years.

Therefore, inspired by Burek and Stilwell (2007) and following the plea of Larwood and Durham (2005) and Silva (2009b) to involve students and staff in geodiversity, a website was designed and initiated with the purpose of divulging geological aspects present in the faculty campus that, otherwise, could easily be missed (see Silva 2013): "Geodiversity in the Faculty campus."

In the website, apart from a general geological characterization of the campus area, describing the rocks, geological units, age, and geomorphological features in that particular city region, a series of geodiversity aspects are focused, ranging from fossils and diagenetic features to rock types, their use as ornamental stone, etc. In conjunction with this geodiversity website, a series of foldable "microfield guides" in A6 standard format – downloadable in pdf format – is being prepared. The guide for Jurassic crinoid fossils (Silva 2014) is already available online (so far with an average of 20 reads per month). Other guides related to the already available website topics, focusing *Turritella* Miocene gastropods, Jurassic brachiopods and belemnitid mollusks, ornamental stones, and stylolites, are currently being prepared.

8.3.3 Going One Step Further: The Cloud of Geospots

Going one step further in the use of urban geodiversity trails supported (or not) by information available in websites for all those interested to use would be to create a "cloud of geospots." This so-called cloud of geospots would allow, in a predefined and easily accessible urban area, to conduct diversified theme or mixed geoeducational or geoawareness trails and activities (Fig. 8.6). Instead of the traditional "one trail fits all" philosophy, one would have the opportunity to customize the activities by means of selecting specific geospots from the cloud that could be organized in trails (or other actions, e.g., treasure hunts) with varied educational or even edutainment objectives. This way, instead of, e.g., teachers having to adapt to existing fixed theme trails, the trails could be fashioned by them – from a broad selection of geospots – integrating their own resources, i.e., practice sets, observation protocols, discussion questions, etc., to better suit their teaching goals.

The geospots in the cloud could be pre-organized in theme trails and activities that would fit common curricular goals such as shown in Fig. 8.6 (A, B, and C), e.g., observation of different types of igneous rocks, sedimentary rocks, and fossils. Alternatively, they could be used to fashion mixed, customized trails, fusing elements of the various other trails (Fig. 8.6, D), for instance, fossils, the sedimentary rocks that contain them, and intrusive igneous rocks (to show that the latter do not contain fossils).

As with other actions described and discussed in this work, the websites and urban geotrail activities supported or not by GPS-capable devices may be approached from different perspectives. In geoawareness, edutainment, or merely recreational activities for the general public, it is more effective to provide the website and the information on the stops selected for the trail (guided or autonomous). For the educational community, apart from using them as described above, an alternative approach would be to build the trails and the websites from scratch – searching and selecting the spots and gathering the information needed, etc. – as part of an outdoor geoeducational activity or exercise.

As an educational bonus, selecting the geospots, generating the relevant information for each one of them, and organizing it in order to design and build the websites turn these actions into multidisciplinary activities, involving not only geologic skills but also physical (it is an outdoor activity), linguistic, artistic, historical, and computational skills, etc. In addition, urban young people are typically attracted to technology and the use of technological novelties and gadgets, and this will be a way of – using that natural inclination – channeling their interest into geology.

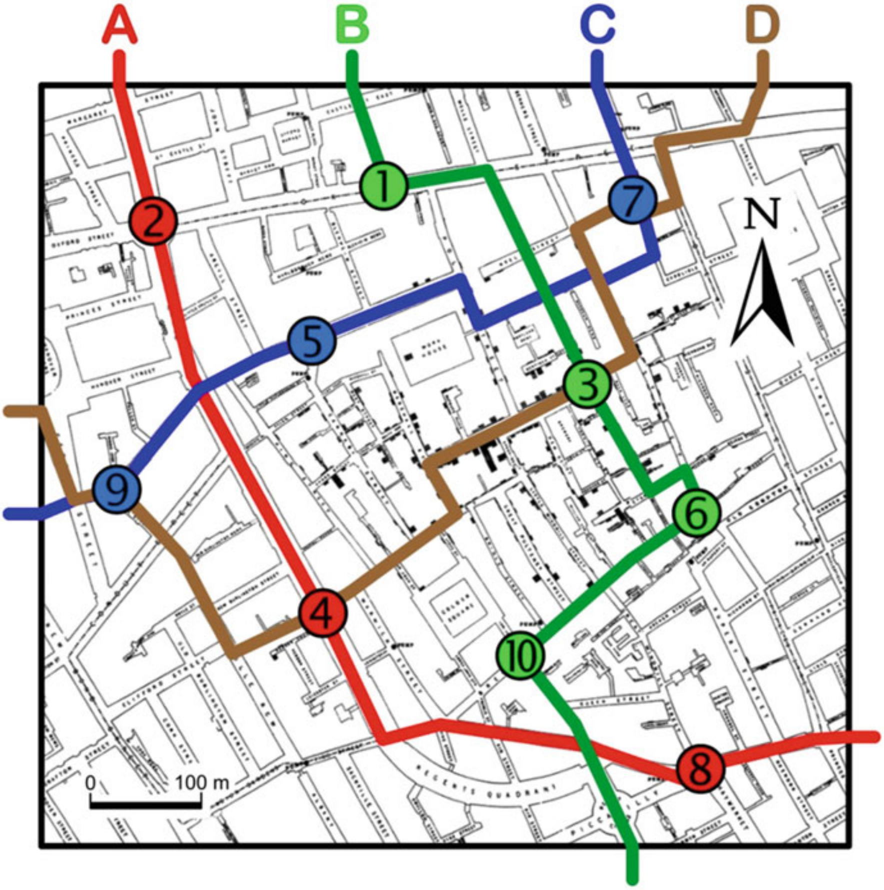

Fig. 8.6 Conceptual diagram of the "cloud of geospots" in an urban environment and of the way of using it in outdoor geoeducational trails. Theme trails: (*A*) sedimentary rocks and depositional environments, (*B*) igneous rocks, (*C*) fossils. Mixed trail: (*D*) customized trail, combining – e.g., for educational purposes – aspects of trails A, B, and C

8.4 GPS-Capable Devices, Field Trips, Geocaching, and EarthCaching

Primates are a playful lot. Among them, much of the learning occurs during youth. Immature offspring plays the most, and by playing with each other and with what surrounds them, primates explore the world they live in, and by doing so they learn.

Humans – as primates – are no exception. In addition, we are a neotenic species, whose prolonged immaturity is key to extended learning, which eventually led to the emergence of elaborate communicative and cultural practices (Edgley 2013). And with new gadgets and technological novelties, new ways of playing games are made possible.

Geocaching fits this scenario like a glove; it is an outdoor recreational activity, in which participants use technological gadgets – Global Positioning System capable mobile devices – to, with the help of preposted geographical coordinates called waypoints, seek objects or containers designated "geocaches" hidden both in natural and urban settings worldwide. In other words, it is a technologically assisted glorified treasure hunt.

Geocaching was born on May 2000, when the accuracy of GPS technology available to the public (i.e., to civilians) was improved tenfold. Immediately the idea arose to use this new opportunity to organize a worldwide treasure hunt. The concept spread rapidly in the Internet and was readily embraced by hundreds of people excited by the prospect of hiding and seeking stashes. However, for Internet geeks all over the world, this time the new game had a twist: it implied leaving the computer and going outdoors to participate. As a simple measure of the success of geocaching worldwide, it is enough to say that currently there are more than 2.8 million geocaches hidden all over the globe.

The usefulness and application of geocaching in teaching and learning is well known and has been broadly discussed and documented (e.g., Matherson et al. 2008; Vitale et al. 2012; Zecha and Hilger 2015). Although originally oriented toward outdoor and nature enthusiasts, geocaching for some time now has crossed over into the urban educational space, even into social studies: "Social studies teachers use geocaching to encourage students to research and visit important local historical landmarks, learn longitude and latitude, and connect content learned in the classroom to actual places and people" (Matherson et al. 2008: 81).

EarthCaching is an adaptation of the geocaching concept, featuring geological aspects – landforms, fossil occurrences, rock formations, etc. – as the cache to be found. EarthCaches may be created and registered in the proper site (www.earthcache.org), or they may be designed and made available independently with the purpose of generating a specific geoawareness or geoeducational activity. EarthCaching, as geocaching, is an autonomous activity. The geographic coordinates of the "treasure" to be hunted are made available – traditionally posted online in a website – by the person or organization fostering the activity, and the participants, after downloading the waypoints and installing them in a GPS-capable device, find the cache on their own.

In order to assure some kind of feedback from the independent participants, some sort of validation of the discoveries is required. Validation has its own rules. In geocaching, the discoverer should register the serial number of the cache (if it is an "official" one) in the website providing the waypoints (e.g., www.geocaching.com). In EarthCaching, more often, the validation is made by means of a photo of the participant and its GPS device next to the geological feature designated as the treasure. On how to submit an "official" EarthCache, and the guidelines for submittal, please refer to The Geological Society of America (2013).

8.4.1 Geoawareness and EarthCaching in the Cape Espichel Area (Portugal)

Within the scope of the "Geology in the summer" initiative sponsored by the Portuguese Agência Ciência Viva (Live Science Agency), in 2007 and 2008, the action "GPS – Geologia por Satélite" (Geology via Satellite, loosely translated from the Portuguese) was created. In Portuguese, the designation of the action is a *double entendre* – intended to entice people's attention to it – using the well-known GPS acronym, standing for Global Positioning System, and the name of the action "Geologia por Satélite."

The logistics of organizing guided geodiversity trails in natural settings is intricate, especially when human and financial resources are scarce. Therefore, this action was designed to promote independent geodiversity walks using the basic rationale of EarthCaches, making it appealing to the growing geocacher's community and at the same time adapting it to the geoeducation and edutainment purposes of the action (Silva and Cachão 2007).

The action was anchored on two strong points: (a) a website attracting people looking (browsing) for geocache and EarthCache activities in the Lisbon-Setúbal area of west Central Portugal and providing appealing information on the geosites (Fig. 8.7) and (b) an attractive outdoor activity directed to geocache and EarthCaching enthusiasts giving them the chance to seek paleontological occurrences of dinosaur tracks and trails (Fig. 8.8) that – back then – were not easily found by nonspecialists.

In the homepage of the activity's website, special attention was given to explaining the rationale of the activity – getting to know local nature and learning to value it – and to providing information about geodiversity and its values, as well as about the need for respecting and preserving natural sites. The five sites selected for this outdoor activity were appealing – mainly dealing with dinosaur tracks – well known, from a scientific, cultural, and educational perspective alike (e.g., Antunes 1976; Santos et al. 1992, 2008); Lockley and Santos 1993; Santos 2008; easily to moderately accessible; and evaluated as not particularly vulnerable to independent public visitation.

The sites selected for this activity mingle strictly geological and paleontological aspects with educational and cultural ones. For instance, the "Pedra da Mua" (Cliff of the Mule) sauropod dinosaur track site in Cape Espichel is famous for having generated the medieval legend of "Nossa Senhora da Mua" (Our Lady of the Mule). As the thirteenth-century story goes, an astounded local fisherman once observed a gigantic mule carrying Our Lady and Baby Jesus climbing the sea cliff and leaving behind enormous footprints: sauropod dinosaur-fossilized tracks! To this day, on the top of the cliff, there is a small chapel adorned with a charming eighteenth-century tile paneling with a series of images depicting the story.

Furthermore, activities like the ones herein described may successfully mingle biotic and abiotic natural aspects. After all, as stated, e.g., in Silva (2008), our world is a unity, and it is geobiological in nature! For instance, the Cape Espichel coastal

Fig. 8.7 General composite aspect of a webpage of the "Geology via Satellite" website, EarthCache-like activities in the Cape Espichel area (Setúbal region, Portugal). This webpage, named "Up there, there are dinosaur tracks," provides general information on the dinosaur tracks in that spot of the Cape Espichel area, as well as the necessary GPS waypoints to find them (See Silva and Cachão 2007)

area with lime-rich soils (Jurassic and Cretaceous limestone substrate, geodiversity, and biodiversity interaction!) is well known for its orchid diversity and bird-watching potential. However, the majority of orchids flower during spring and some birds migrate in winter. Geological aspects, e.g., rock formations, dinosaurs tracks, and landforms, on the other hand, are always there, no matter what the climate conditions may be or the season of the year.

Since these activities are autonomous, it is advisable to find a way of getting some sort of feedback from the participants. In this case, the participants were asked to fill in a short questionnaire on the activity (available online) and send a photo of

Fig. 8.8 One of the caches in the “Geology via Satellite” EarthCaching-type activity in the Cape Espichel area (Portugal) is the Lagosteiros track site. In this location, apart from a beautiful Atlantic landscape, a long bipedal ornithopod dinosaur trail (seen in the picture as an alignment of rounded dots; for the interpretation of the tracks, see Santos et al. 1992 and Santos 2008) and a short theropod track may be observed. Length of the individual footprints: 40–50 cm

themselves – a selfie would be fine – next to the “EarthCache” in exchange for a booklet on the paleontology of the area.

8.4.2 Geoeducational EarthCaching in the Lepe Region (Spain)

If in the Cape Espichel action described above the main target audience was the general public, in a later activity conducted by Mayoral et al. (2009a, b), the target were university students.

Most of the activities described in this chapter fall under the category of “nonformal learning”: “Non-formal learning consists of learning embedded in planned activities that are not explicitly designated as learning, but which contain an important learning element” (Colardyn and Bjornavold 2004: 71). When it comes to EarthCaching, if we see them from a “nonformal learning” point of view, this means that each cache should be related to some kind of lesson to be learned in the field of earth sciences, such as general geospatial skills, earth literacy, and learning-related skills (The Geological Society 2013). The “geoeducational EarthCaching in Lepe” may be, of all these activities, the most “formal” one when it comes to learning since it was designed as part of the paleontology course of the Geodynamics and Palaeontology Department, Huelva University.

This activity was the result of an Iberian experience of geoteaching cooperation between the University of Huelva and the University of Lisbon. This cooperation may in the future be extended to other aspects of the paleontological courses taught in both geological departments.

As in any other geological discipline, fieldwork is paramount in paleontology. The information needed for paleontological research comes from fossil assemblages. These occur originally in natural geological settings. Hence, the main goal of these GPS-assisted paleontological outdoor activities is to stimulate students to actively and passionately engage in fieldwork, giving them the tools they need to perform field tasks autonomously, providing them with the necessary skills for their future professional career (Mayoral et al. 2009a). Outdoor activities such as the one presented herein – taking place in a relaxed environment and basically following a "treasure hunt" EarthCache mode, appealing to the "adventurous" side of fieldwork – also have a high potential to attract students from other scientific areas or disciplines to geoawareness activities.

This GPS-assisted activity follows the general protocols of EarthCaching. The waypoints of the geological outcrops may be easily downloaded by the students from a specially designed website (Mayoral et al. 2009b). The website, apart from the waypoints, includes geological and paleontological information on the geological outcrops and the description of tasks to be performed by the participants on the spot. The coordinates may be manually inserted into the GPS device or directly downloaded to a smartphone with GPS capability or, after processing it with any GPS software, uploaded directly to a GPS device. The waypoints provided correspond to a set of geological outcrops of special paleontological interest where the students are required to perform a number of fieldwork tasks.

An important element of these activities resides in its focus on the learning features, especially the methodological aspects of EarthCaches, like explanatory texts, illustrations, and tasks to be fulfilled by the student. In this activity, the tasks are described in a document in pdf format that the participants download from the website supporting the activity: e.g., measuring the stratigraphic section, identifying the most abundant fossils present, taking photos of relevant paleontological aspects of the fossil assemblage, geotagging the photos and adding a descriptive geological caption, etc. (see Mayoral et al. 2009c). As a corollary of the activity, in order to validate their findings and observations, the students must send a message to the coordinators of the activity, mentioning their name, date of discovery, and a digital photo of the participant holding a GPS-capable device close to the discovered paleontological object or post-geotagged photos of the visited sites, with their findings (Fig. 8.9). The results of this EarthCaching activity using GPS-capable devices such as smartphones converge with the expectations expressed by Downward et al. (2008) who predicted that mobile technologies that integrate GPS devices and live streaming of data will further enrich the integration of very different learning spaces by promoting real-time feedback of observations and queries between those spaces.

As in all the autonomous activities herein described, all participants will be alerted to the compliance of a fieldwork code of conduct. The commitment to natural diversity preservation (bio- and geodiversity) is paramount in these activities.

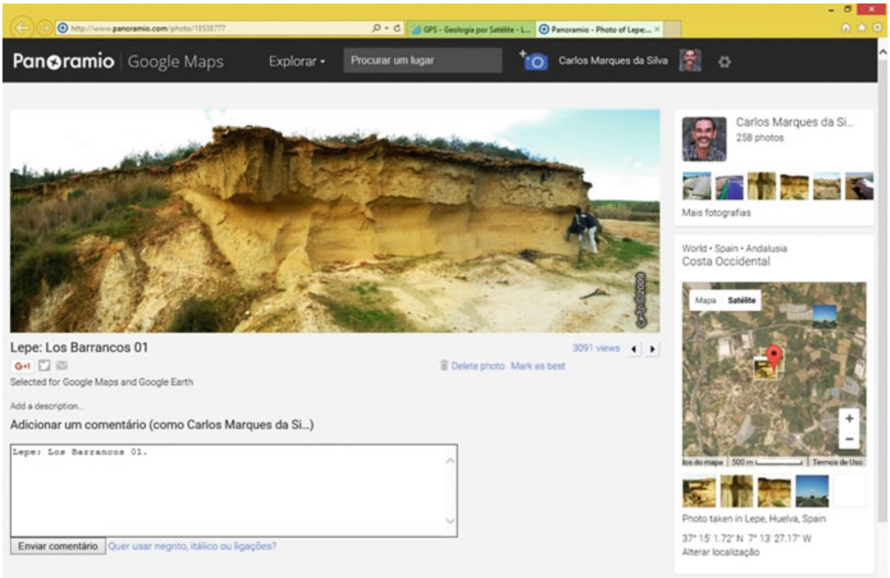

Fig. 8.9 Los Barrancos outcrop in Lepe (Andalucía, Spain). One of the geotagged photos used to support the EarthCaching activity in Lepe. This photo was tagged in the category "geodiversity" among the geological photos of the author and since February 2009 was viewed 3091 times. As a reminder of the exposure these geotagged photos may receive, some of the "geodiversity" pictures in this account were viewed more than 34,000 times in 6 years

The information provided and the tasks to be performed are based on accurate and updated geological information and aimed at developing autonomous fieldwork skills. For detailed information on the sites available for this activity in the Lepe region of Andalucía (Spain), please refer to Mayoral et al. (2009a).

8.5 Share Geodiversity, Share Nature, with Geotagging!

Humans are social animals, and, therefore, most people have an irrepressible urge to share their thoughts and experiences, from the most meaningful life-changing events of their existences, "Fatherhood changed me! Do you want to see pictures of my kids?", to the utmost trivial ones, "You will not believe what I had for breakfast today! Here, look at this photo!"

Therefore, small wonder that the central idea of social networks, such as Facebook and Twitter, and web application hybrids (also known as mash-ups), such as Panoramio and Flickr, capitalizing on this basic human trait, is to share thoughts and experiences, but more often photos and videos. After all, apart from being social primates, we humans are also visual animals. When we want to express an opinion, we frequently say "As I see it," not "As I smell it" (e.g., Silva 2010), and it is a well-known fact that "a picture is worth a thousand words."

For geological and educational purposes, posting photos of aspects of geodiversity in social networks may be useful – for geoawareness and science popularization proposes – but does not really reach the potential of geotagging. Geotagging is a form of georeferencing that consists in adding geospatial information (commonly geographical information, latitude, and longitude) to digital media (photos, videos, SMS messages, QR codes, webpages, etc.) in the form of metadata for effective location, visualization, and analysis.

Photos are by far the most commonly geotagged items. There are two main methods for geotagging photos: (a) the low-tech manual way, uploading the photo to a geotagging web mash-up such as Panoramio (Fig. 8.9) or Flickr and manually dragging and dropping a location pin onto the mash-up digital map in the location where the photograph was taken, and (b) the high-tech automatic mode. The photo is positioned on a digital map by the software which makes use of the metadata automatically added to it by the digital device that captured the picture (digital camera or smartphone). The manual mode described above may be enhanced by getting geographical coordinates from a conventional GPS receiver having its clock synchronized with that of the camera or by using the information from GPS waypoints marked in the spot where the picture was obtained. For a general review of basic geotagging techniques, software, and popular geotagging web mash-ups, please refer to Welsh et al. (2012).

8.5.1 Geotagging in Educational and Recreational Settings

Geotagged photos may be used in a variety of educational, edutainment, and recreational situations. In education, it is an innovative method that brings together several traditional fieldwork practices. It is not meant to replace field notes; instead it may successfully complement them. If students annotate their geotagged pictures and add further considerations on them post-fieldwork, then geotagging could act as a complement to traditional fieldwork notebooks, promoting critical reflection and boosting learning. Therefore, geotagged photographs have the potential to encourage post-fieldwork reflection (Welsh et al. 2012). Geotagged photos have been used by Mayoral et al. (2009a, b) to guide students on the autonomous field trips in the Lepe EarthCaching activity described above (Fig. 8.9). The photos were manually geotagged in Panoramio and could be accessed both in Panoramio and Google Earth on laptops and PCs at home, preparing the fieldwork, or in smartphones – using 3G coverage – directly in the field.

In edutainment and recreational settings, both in urban and natural areas, it is an excellent way of documenting the sites to visit in geodiversity trails. Geotagged photos posted in mash-ups such as Panoramio, Flicker, etc., will be seen by thousands of people all over the world every year, fetching an audience hard to match by any other means. This type of exposure is paramount in geodiversity popularization and a major enticement for students of all learning levels to adhere to activities involving geotagged photos.

8.5.2 *Cities and Technology: Geotagging Urban Fossils*

An interesting web application hybrid specifically designed for geotagging photos of urban fossils was recently created: Paleourbana (www.paleourbana.com) (Fig. 8.10). This mash-up combines the two elements that have been the Ariadne's thread of this work: linking urban outdoor geodiversity activities with new technologies. Since its inception in 2015, Paleourbana's digital map was updated with more than 250 sites of urban fossils in 54 cities around the world. And it may be reached via Twitter and Facebook.

Photos geotagged in this type of fossil-oriented web application hybrids may be used with success to support city trails (as discussed above). They could be used to

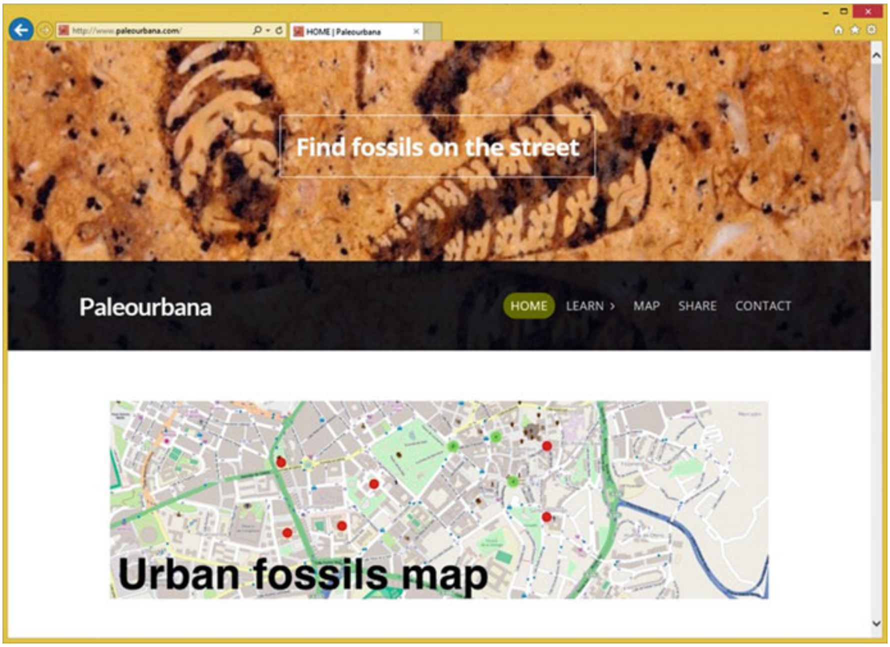

Fig. 8.10 Homepage of Paleourbana. This mash-up combines the two elements that constitute the Ariadne's thread of this work: linking urban outdoor geodiversity activities with new technologies. Since its inception in 2015, Paleourbana's map was updated with more than 250 sites of urban fossils occurring in 54 different cities around the world

provide visual information about the geodiversity aspects – in this case paleontological – that may be seen on the trail and help the participants to select the walks with the fossils they find more appealing. For teachers, students, and the general public alike, such web application hybrids as Paleourbana could help characterize the cloud of urban geospots (as described above) available for urban geodiversity activities and become a key tool to help select the spots to customize mixed themed urban geodiversity trails.

From a teaching point of view, this mash-up is an excellent tool for educators to provide the ultimate reward to their students for geodiversity activities in urban areas, even in the school itself: the possibility of sharing with others their findings and, by doing so, to contribute to a better knowledge of urban geodiversity in the city and to make formal school exercises useful for the larger community of urban paleontology enthusiasts.

8.6 Conclusion: The "Geoeducational Bundle"

In our present-day urban and technological world, we commonly have access to resources that a few decades ago would be seen as pure science fiction. Smartphones, computer tablets, GPS devices, Internet, mobile apps, web application hybrids, etc., are increasingly accessible in urban areas around the world. Soon, novel technologies will be added to this already long list: virtual reality, drones, 360° photography and videos, enhanced reality, new gadgets, and technologies yet to be developed! Who knows what the future will bring us!

Several independent international studies have shown that nonformal learning practices provide 60–80 % of the total learning (Zecha and Hilger 2015, based on OECD 2012 data). Much of the activities described and briefly discussed in this work fall into this learning category, but could easily be adapted to formal learning contexts. The importance of these activities resides in its focus on the learning aspects, especially their methodological content, such as explanatory texts, illustrations, and tasks to be fulfilled by the participants, assisted by the use of technology in order to create new learning activities and entice students to participate and to acquire skills (such as GPS orientation and geotagging) these days increasingly commonplace in geology but unheard off a few decades ago.

The core idea here is not in as much to create new technologies especially designed to be used in outdoor teaching and popularization geological activities, but rather to use the existing ones – the ones that are today so widespread that we now take them for granted – in novel and imaginative ways. Moreover, many of these resources – once you have the hardware – are available online for free. Used collectively they may be fused together into an integrated and interactive technological geoeducational bundle (Fig. 8.11), contributing to the attractiveness and the success of outdoor geological activities. Nowadays people can go outdoors – even into the countryside! – with their GPS-capable devices, get information from websites on their smartphones using QR codes, take notes and pictures of interesting geological

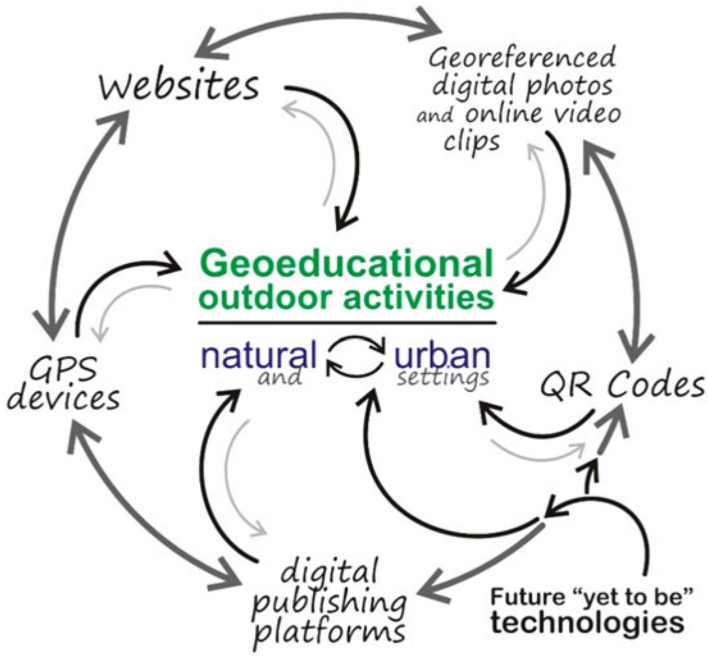

Fig. 8.11 Conceptual diagram of the integration and possible interactions among the elements of the technological "geoeducational bundle" for outdoor activities. Emerging technologies such as drones, virtual reality, and 360° photography and videos may be incorporated, as well as future yet-to-be-developed technologies

aspects, integrate them, and post them immediately on social networks or as geotagged commented photos in mash-ups such as Panoramio or Paleourbana.

As a final note, one must have in mind that the integration of the elements of the technological "geoeducational bundle" is a dynamic and interactive process (Fig. 8.11): on the one hand, new technologies are being used in geoeducation, changing the traditional way of dealing with it, but, on the other hand, the usage these technologies were originally designed for is also being modified and adapted in novel ways as a result of the know-how ensuing from their educational use.

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