Smartphones for Teaching and Learning With Engineering Students^{*}

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Analysis of geological structures provides important information on the thicknesses, declivities, and volumes of rock removed, for example. In this paper, an alternative method of calculating approximate thicknesses and volumes of geological structures is presented through the use of smartphones and satellite technology. The method consists in taking photographs with digital wireless devices of the wall of the geological structure to study from a known position and distance. Through a program of analysis of images, photographs were dimensionally calibrated and digitally processed to get better detail. Moreover, via the applications of smartphones (Global Positioning System (GPS)), the work areas were located at Google™ Earth to determine their surface area, which was calculated with the transfer of images to AutoCAD® software. The determination of the thickness and volume of rock and material extracted with the methodology proposed here, show simple forms of work and quite accurate, which would otherwise be extremely complex for determination.

Keywords: image analysis, particle size, rock volumes, scales, smartphones, slopes

Introduction

Current forms of production of scientific and technological knowledge, its effects onto the nature, the society, and human beings, as well as specialist's analysis around the social impact of technology, are issues that cannot be left out of the design curriculum at all levels of educational training, mainly due to the diversity of ways through which the students can acquire the knowledge, especially in the case of teaching of science and technology.

Here, the advent of the Internet, mobile digital technology, and Web 2.0 (Wang, Bryan, & Steinke, 2013), and thus mobile learning (m-learning) (Motiwalla, 2007), has led to significant and radical changes in the way of access to information, because the way people work, manage their lives, purchase products, process information, and even how to relate, has been adapted to these media.

Thus, according to Relaño (2011), there are new trends and adaptations in terms of connectivity, control, customization, education, commerce, and communication, configuring a new type of user accustomed to the digital world, which require greater information flows where visual literacy is extremely important in learning (Van Eck, 2006). That is why the application of information and communications technology (ICT) into the

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organizations, businesses, and educational institutions goes beyond building a data processing system and instead seeks to analyze not only how to improve their actions using the facilities of existing technologies comprehensively, but also involved in the implementation of new devices and their use in the teaching and learning process (Scott, 2000). That is, the transformation requires not only equipment and technology to increase productivity, but also new forms of management, organization, and training necessary for the development of human resources (Bada & Madon, 2006).

Within this framework, higher education has always been a key and decisive factor in the processes of human development, where this scenario is enriched and expanded thanks to the great innovative and intelligent exploitation of new technologies, increasing its power to impact on societies according to the statement by Reeves, Herrington, and Oliver (2005).

At the height of the information society, greater access to information, however, does not in itself mean increased citizen participation mechanisms to knowledge or improved living conditions from the alleged manipulation and use of technological inputs tip. Culture and digital art are certainly in vogue, are slowly making inroads in academia (Balubaid, 2013), and are bringing a new type of user characterized by levels of connectivity and requires very high technologies, what seem to make them digital individuals (Mäntymäki & Riemer, 2014) very informed and updated.

The rapid development of technology in the process of industrialization creates an increasing need to train professionals' engineering versatility and ability to cope with the challenges imposed by the environment in which they operate. In essence, engineers trained are required under the premise of academic and professional excellence and, as expressed by Kamp and Klaassen (2013), engineers must be holders of clarity and depth of knowledge and have a robust systematic approach to solving required problems and with interdisciplinary attitude.

Universities and higher education institutions in engineering are faced with an unavoidable challenge in shaping curricula in line with the demands of the global marketplace. Engineering education is a challenge facing this new scenario continuously modernized and renovated. The teaching and learning process involved in the formation of an integral engineer must be based on the development of student skills aimed at solving problems effectively; some of them based on thorough analysis of the problem and possible solutions and establishing connections between this problem and the technical/scientific knowledge required to solve (Felder, Woods, Stice, & Rugarcía, 2000).

In this line of thought, teaching and learning, at engineering level, is no stranger to technological change, and today, the presence of ICT is a reality in different universities globally (Salinas, 2004); thus, mobile digital technology reveals other forms of distance learning (d-learning) under the concept of m-learning as TV-based interactive learning (t-learning), electronic learning (e-learning), or blended learning (b-learning), which has great support access to open educational resources (OER) (DeVries, 2013). In this vein, the teaching and learning process via m-learning is greatly facilitated by the connectivity of smartphones, which are considered at present as one of the most important technological developments made today, allowing the mobile and quick accessibility on one hand, and on the other, its impact on the immediacy of communication and information exchange.

Today's increasing mobile accessibility by virtually all social sectors, including obviously the student sector, is causing changes in attitudes and habits of individuals, hitherto unthinkable, such as the use of these devices coupled with the emergence of social networks for the exchange and dissemination of information

within or outside learning communities—knowledge networking (Chatti & Jarve, 2007). In this situation, the educational environment cannot remain oblivious to these developments and to incorporate new teaching methods, not only the facilities that these technologies can provide, but must also take into account new learners' characteristics of learning.

In the academic environment, regardless of the status of digital natives or immigrants (Scott, 2000), in a highly technical environment surrounded by mobile accessibility, and agree with all the above stated, the present study aims to illustrate the use of mobile digital technology (smartphone) as a tool of learning for the acquisition, analysis, and design of data, in this case applied to calculate geological structures with Civil Engineering students at the Veraguas Regional Center of the Universidad Tecnológica de Panamá.

Methodology

Participants

In the different phases of development of research, a total of 25 students regularly enrolled in the course of Geology at Semester II, 2014, at the Regional Centre of Veraguas of the Universidad Tecnológica de Panamá in Civil Engineering, was involved.

Resources

Thinking about the development of technological resources designed specifically for use in this study, it was necessary to define two groups of main resource: (a) experimental technological resources on-line and off-line; and (b) resources of interactive computer technology.

While both types of resources are designed for joint and coordinated use in the classroom place work of the subject, they have fundamental differences in terms of learning opportunities from activities that generate them. The activities were conducted through mobile devices of different types: Samsung[®] Galaxy Pro GT-B5510L, Samsung[®] Galaxy Mini GT-S5570L, Samsung[®] Galaxy Ace GT-S5830L, Xperia Pro MK16a, Samsung[®] Cativate Glide, among others.

Didactic Learning Activities With Smartphones

Various experiences of learning were performed both in and outside the classroom (day out) and in the laboratory using teaching material as smartphones and different applications both on- and off- line. To start implementing these teaching strategies, the research starts from the premise that students must answer a series of questions related to the topic to develop and implement, when necessary, they should make manuals graphical representations. In the next moment at the experiences, the students should use their mobile device, with the respective applications intended to corroborate or not what was discussed in class. Finally, a discussion was held relevant, guided by the teacher and passed the following experience. Table 1 shows the experiences and developed detailed topics.

Scale photography. Figure 1 represents graphically how the photographs were taken with the smartphones to study the different geological structures.

At a distance from the structure considered, the students were positioned to capture images, upon placement of a material with known longitudinal dimensions (H). After the capture, the images were printed and, in the classroom, their respective scale was determined by measuring the printed image and the size of the reference material, and using a rule of three, the scale of the photograph was determined. After determining the scale, the students proceeded to determine declivities, identify the stratigraphy of the area, and compare with

manual design made.

Table 1

Educational Content Addressed With the Use of Smartphones in and out of the Classroom and/or Academic Laboratories

Applications	Development content	Place
GPS, inclinometers, and compass	Determining the erodibility of the bank of a river and riverine predicting changes	Outside the classroom
	Geo-referencing of landslides, slope of embankments, and other structures	
Camera	Determining the scale of the photograph	Outside and inside the classroom
	Determination of height and declivity of a natural slope	Outside the classroom
	Determination of average particle size of solid grains with importing images to AutoCAD® and calculations in the Microsoft Excel®	Inside the classroom
	Identification in Google™ Earth to calculate the volume of rock extracted from an abandoned stone quarry	Outside and inside the classroom
Access OER	Proficiency test on instructional documentary online	Inside the classroom

Figure 1. Starting setup for imaging of geological structures studied with the smartphones.

Changes at the edges of a river. When changes occur at the edges of a river due to erosion, it is extremely important to know how much has been modified outside it over a period of time. This determination can be made with the Global Positioning System (GPS), which is accurate but expensive. However, smartphones with free Apps (GGRS87) provide geographic position information, which is not as accurate, but show acceptable and useful data. The data obtained in the field were launched in Google™ Earth and old aerial orthophotos (picture five years ago) succeeded in identifying the stretch studied. The data were exported to AutoCAD® or Civil3D® to calculate areas.

Particle size. For determination of the particle size of solid particles, the students were asked to take a photograph of the particles as perpendicular as possible (see Figure 2). The images captured were passed grayscale and then transferred to AutoCAD®. With this software, the students determined average equivalent particle diameter by two methods: (a) by the projected area; and (b) by the measurement of the contours. The data gathered were transferred to the Microsoft Excel® where relevant calculations were performed.

Volume of mined rock. In this field experience, the students took photographs of a stone reservoir abandoned along geo-referenced and with the GPS smartphone data, and they located the area on Google™ Earth. The identified image of the site was transferred to AutoCAD® for determining its superficial area. With the height data obtained in field reservoir and the area determined, they calculated the volume of extracted rock.

Figure 2. Photograph of grains of soil particles, to determine its average size.

Results and Discussion

Previous research allowed determining the profile of the undergraduates in this higher education center (Kennedy, Judd, Curchward, & Gray, 2008) and the main findings are as follows:

1. Ninety-four percent of the enrolled students come from a college of education of the public network;
2. The female population has the highest percentage (53%);
3. With regard to student's family income, 48% said that they have an income below \$450 per month, while only 13% receive more than \$900 family income, and this budget ranges;
4. Seventy-one percent of the students come from a background of private school education.

Studies with college students found that emerging technologies were not in general use, which seems to be repeated in the present study (Chatti & Jarve, 2007). Although many students use a wide range of technologies, areas where the use and familiarity with technology are far from universal in the university were evident.

This is reinforced by a number of constraints ranging from the socio-economic, cultural, and ethnic formation, gender characteristics, and specialization careers studying, such as intervening variables that should be studied in depth. Similarly associated with this disparity in access to technology use and skills, attitudinal characteristics and requirements attributed to the generation of digital natives, where the educational process should be equitable.

Once, the students' profile was known, this research proceeded to carry out the teaching practices with the use of smartphones. In Figure 3, it can be seen how the students use their mobile devices in the field, not only to capture images of geological structures, but also to record explanations given by the teacher on methods of determining declivities, geographical direction, and sense.

Figure 3. Set photo using smartphones in the field and capturing the explanation of the declivity of land.

Soil Profiles and Structure Recognition

Initial field practices were conducted in an isled region that is being used in the removal of material for civil construction. Once in the field, the students were asked to design the soil profile that was shown and subsequent image capture with their smartphones.

With the printed photography, in the classroom, the students had to compare manual drawings with the picture taken and identify the various constituent elements of the relief, which was indicated by the teacher (see Figure 4). With the above activity, the students were able to identify: (a) thickness plant cover and height of trees; (b) different soils by changes in coloration; (c) declivities of soil and underground strata; and (d) maximum height of the hill.

Figure 4. A hand drawing of a hill and a photograph of soil profile taken with smartphones to identify structural elements.

Soil Volume Slipped

In the study region, it was able to verify a volume of soil slipped because the instability of the base of the slope and constant rains, typical of the era. In this sense, the students were asked to estimate the volume of soil displaced. For this purpose, with their smartphones made shots from different angles and with the scale of the photograph and identifying the geometric type defined by slipping (triangle), they proceeded to calculate the required volume. In Figure 5, images of ground slides studied are presented.

Figure 5. Ground sliding images (side and front) to identify its geometry and calculate the volume displaced.

Abandoned Quarry Stone's Location and Material Extracted Calculation

In this activity, an abandoned quarry was visited in order to geo-reference it with the use of GPS for smartphones and subsequent calculation of the volume of extracted rock. The students must capture images of the sides of the excavation to determine its height and with the GPS data to locate the region in GoogleTM Earth,

later to outline the image and extrapolate to AutoCAD® or Excel® to determine its surface area. With the elevation data and the area of excavation, it was able to determine the volume of extracted rock. Figure 6 presents some images.

Figure 6. Geo-referencing of abandoned quarry stone and procedure for calculating volume of extracted rock (Observation notes made by the students).

Determining the Erodibility of a River

The action of external agents (such as temperature, wind, water, etc.) originates processes that cause changes in the surface of the relief. In this regard, the students were asked to geo-referenced some points along the stretch of a river and subsequently be located such data, onto images of orthophotos from previous years and/or Google™ Earth, to see if it had changes or not in its location along the period of time. The data obtained with the GPS smartphone over the river were analyzed by the students, with software like CivilCAD® and AutoCAD®.

For the part of selected river, the students analyzed individually each point geo-referenced and determined its displaced distances and/or eroded onto based images of 2009. The distances were averaged for each surveyed point, and the calculation of erosion resulting 2.96m/year.

Similarly, the students modeled a polygon based on images from 2009, which was divided in order to calculate the eroded areas over time. According to calculations made by the students, the average volume of eroded material was 136.43m³/year. The students should make conversions from Universal Transverse Mercator (UTM) coordinates to geographic coordinates or vice versa, as required. Figure 7 shows images of the stretch of the river studied.

Figure 7. Images used by the students for determining the volume of material eroded in a river.

Conclusions

Once this study is completed, it is concluded that:

1. The didactic and procedural strategies developed are part of a pedagogical model that adopts the

incorporation of mobile digital technology for teaching engineering, so it allowed the introduction of strategies and appropriate educational interventions;

2. The characteristics revolved around, mainly to the flexibility and dynamism in the use of smartphones, so that its introduction and use in educational interventions designed required to own and defined spaces so they could reach the importance planned for teaching and learning engineering;

3. In all developed educational activities, the approaches to the use of smartphones, properly developed and articulated, provided an additional and attractive way with the ability to achieve adequate levels of interest and commitment of students for the study and understanding of geological structures in the field;

4. Finally, the use of smartphones for teaching and learning completes a multidimensional array of educational resources that tend to enhance the quality of meaningful and authentic learning of contents studied. Thus, vicarious learning is transformed by a direct educational experience which appreciably increase the possibilities of visualization, interaction, and student experimentation with a particular dynamic context of engineering interest.

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