Using Smartphones and Digital Technology to Calculate Volumes of Geological Structures with Civil Engineering Students

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Abstract—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 processing them to get better detail. Moreover, the applications of SmartPhones (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.

Index Terms—Image analysis; particle size; rock volumes; scales; smartphones; slopes.

I. 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 designs curriculum at all levels of educational training, mainly due to the way they can acquire the knowledge, especially in the case of the teaching of science and technology.

Here, the advent of the Internet; the mobile digital technology and the web 2 [1]; and thus the mobile learning [2] have led to significant and radical changes in the way of access to information; because the way we work, manage our lives, purchase products, information and even how to relate, have been adapted to this media.

Thus according with reference [3], 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 and them prefer an inductive reasoning and own literacy skills, mostly, visual [4]. That is why the application of communication and information technology -CIT'S- into the organizations, businesses and educational institutions, goes beyond building a data processing system and seeks instead to analyze how so they can improve their actions using the facilities of existing technologies; where their technology implementations must be comprehensive, as well as generating new technical devices, you must also take into account how they can be used in the teaching-learning [5]. 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 [6].

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 reference [7].

At the height of the information society, and greater access to information, however, does not in itself mean increased citizen participation mechanisms to knowledge or to improve living conditions from the alleged manipulation and use of technological inputs tip. Culture and digital art are certainly in vogue and are slowly making inroads in academia [8], and are bringing a new type of user characterized by levels of connectivity and require very high technologies; what seems to make them digital individuals [9] very informed and updated.

The rapid development of technology in the process industry, creates the increasingly need to train professionals’ engineering versatile and able 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 reference [10], saying that engineers must be holders of clarity and depth of knowledge and a robust systematic approach to solving required problems and with interdisciplinary attitude.

The universities and higher education in engineering are faced with an unavoidable challenge in shaping curricula in line with the demands of the global marketplace. The engineering education is a challenge facing this new scenario continuously modernized and renovated. The teaching-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 [11].

In this line of thought, the teaching-learning, in engineering level, is no stranger to technological change, and today the presence of ICT is a reality in different universities globally [12]; so that the mobile digital technology reveals other forms of d-learning under the concept of mobile learning as a t-learning, e-learning, b-
learning, which have great support access to open educational resources (OER) [13]. In this vein, the teaching-learning process via mobile learning, is greatly facilitated by the connectivity’s of the SmartPhone, which are considered at present as one of the most important technological developments made today; allowing the mobile and quick accessibility on the one hand and on the other, its impact on the immediacy of communication and information exchange.

Today’s increasingly mobile accessibility by virtually all social sectors, including obviously the student sector and this 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 - [14]. 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 the characteristics of learning new learners.

In the academic environment and regardless of the status of digital native or immigrant [5], in a highly technical and surrounded by mobile accessibility environment; and agree with all the above stated, the present study has as main purpose 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’s students at the Veraguas Regional Center of the Universidad Tecnológica de Panamá.

II. METHODOLOGY

A. Participants

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

B. Resources

Thinking about the development of technological resources designed specifically for use in this study, was necessary to define two groups of main resource. i.e. (i) experimental technological resources on-line and out-line and (ii) resources 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 between them 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® Cattivate Glide; among others

C. Didactic learning activities with SmartPhones

Various experiences of learning were performed both in and outside the classroom (day out) and in laboratory using as teaching material the SmartPhones and different applications both on and off-line. To start implementing these teaching strategies, we start 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, students should use their mobile device, with the respective applications which corroborated or not your previous guesses. Finally, a discussion was held relevant, guided by the teacher and passed the following experience. In the table below the experiences and developed detailed topics.

<table>
<thead>
<tr>
<th>Applications</th>
<th>Development Content</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS, inclinometers, compass</td>
<td>Determining the erodibility of the bank of a river and riverine predicting changes. Geo-referencing of landslides; slope of embankments and other structures.</td>
<td>Outside the classroom</td>
</tr>
<tr>
<td>Camera</td>
<td>Determining the scale of the photograph.</td>
<td>Outside and inside the classroom</td>
</tr>
<tr>
<td>Camera</td>
<td>Determination of height and declivity of a natural slope</td>
<td>Outside the classroom</td>
</tr>
<tr>
<td>Camera</td>
<td>Determination of average particle size of solid grains with importing images to AutoCad® and calculations in the Microsoft® Excell®.</td>
<td>Inside the classroom</td>
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<tr>
<td>Camera</td>
<td>Identification in Google Earth to calculate the volume of rock extracted from an abandoned Stone quarry.</td>
<td>Outside and inside the classroom</td>
</tr>
<tr>
<td>Access OER</td>
<td>Proficiency test on instructional documentary online.</td>
<td>Inside the classroom</td>
</tr>
</tbody>
</table>

D. Scale photography

The figure below represents graphically how the photographs were taken with the SmartPhones to study the different geological structures.

![Figure 1. Starting setup for imaging of geological structures studied with the SmartPhones.](Image 370x207 to 476x367)

At a distance from the structure considered, 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, the size of the reference material and using a rule of three, the scale of the photograph was determined. After determining the scale, we proceeded to determine declivities, identify the stratigraphy of the area and compared with manual design made.
E. Changes at the edges of a river

When changes that 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); are accurate but expensive; however, Smartphone with free apps (GGRS 87), provide geographic position information 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 5 years ago) succeeded in identifying the stretch studied. The data were exported to AutoCAD® or Civil3D® to calculate areas.

F. Particle size

For determination of the particle size of solid particles were asked students to take a photograph of the particles as perpendicular as possible - see Figure 2. The images captured were passed grayscale and from there was transferred to AutoCad®. With this software students determined average equivalent particle diameter by two methods: (i) by the projected area and (ii) by the measurement of the contours. The data gathered were transferred to the Microsoft® Excell® where relevant calculations were performed.

![Figure 2. Photograph of grains of soil particles, to determine its average size.](image)

G. Volume of mined rock

In this field experience, students took photographs of a stone reservoir abandoned along geo-referenced and with the GPS Smartphone data, 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.

A. 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 were 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 identifying the various constituent elements of the relief, which was indicated by the teacher; as shown in Figure 4. With the above activity, the students were able to identify (i) thickness plant cover and height of trees, (ii) different soils by its changes in coloration; (iii) declivities of soil and underground strata and (iv) maximum height of the hill.
C. 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. Students must capture images of the sides of the excavation to determine its height and with the GPS data to locate the region in Google™ Earth, later to outline the image and extrapolate to AutoCad® or Excell® to determine its surface area. With the elevation data and the area of the excavation were able to determine the volume of extracted rock. Figure 6 presents some images.

B. Soil volume slipped

In the study region 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, they were asked students 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 is presented.

Figure 4. Hill’s hand drawing and a photograph of soil profile taken with SmartPhones, identifying structural elements.

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

Figure 6. Geo-referencing of abandoned quarry stone and procedure for calculating volume of extracted rock. Observe the notes made by students.
D. Determining the erodibility of a river

The action of external agents (such as temperature, wind or water, and other) originating processes that cause changes in the surface of the relief. In this regard, we asked students 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 students, with software like CivilCAD® and AutoCAD®.

For the part of selected river, 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, the calculation of erosion resulting 2,96m/year.

Similarly, students modeled a polygons based on images from 2009 and 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. Students should make conversions from UTM coordinates to geographic coordinates or vice versa, as required. Figure 7 shows images of the stretch of river studied.

![Figure 7. Images used by students for determining the volume of material eroded in a river](image_url)

IV. CONCLUSIONS

Once this study is completed, it is concluded that:

- 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.
- The characteristics revolved around, mainly to the flexibility and dynamism in the use of SmartPhones, so that its introduction and use it in educational interventions designed required to own and defined spaces so they could reach the importance planned for teaching and learning engineering.
- 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.
- 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 in which appreciably increase the possibilities of visualization, interaction and student experimentation with a particular dynamic context of engineering interest.

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