Senior High School Students' Perceptions and Attitudes toward the Use of *Google Maps* as Instructional Tool in *Earth Science*

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Abstract This study investigated the use of Google Maps as an instructional tool in Earth Science. A conveniently sampled senior high school class (*n*=34) participated in a formative online Google Map activity. The students inferred the location of landforms usually associated with faults using the *Terrain* view of Google Maps during the pre-lecture and intervention phase. A short lecture explaining how these land features can possibly be deduced using Google Maps followed. After the lecture, the students re-observed the maps with Google Maps, reexamined their previous answers and modified them, if necessary. After the activity, the students answered a self-evaluation form (SEF) which sought to gather their insights regarding the use of Google Maps in their Earth science class. The results revealed that the majority of the respondents expressed positive attitudes toward using Google Maps in classroom learning. They have had meaningful engagement with this online geospatial tool in their lessons in Earth science. However, challenges such as slow internet connection and limited exposure and practice were also noted by the students. Future researchers may look into the application of Google Maps in other lessons or learning competencies, a wider coverage among schools, and the integration of other geotechnologies in teaching the Earth sciences.

Keywords: Earth science, Google Maps, online maps, senior high school, teaching

Introduction

Science education has benefited from emerging technologies such as computer simulations because of their success in facilitating the development of scientific content and process skills (Smetana & Bell, 2012). One of the popular tools in education today is the Geographic Information Systems or GIS which refers to a collection of spatial data and the software responsible for its collection, organization and analysis (Marra et al., 2017). Since the 1990s, educators have tried to teach about and with GIS (Kerski, 2011). In a wide array of disciplines (from the social sciences and humanities to the natural sciences), GIS may be used by students to deepen their content knowledge (Kerski, 2011). For example, in a study among student-teachers, Ratinen and Keinonen (2011) noticed an improvement in the participants' geographic knowledge after engaging in a GIS-based PBL. Likewise, GIS can be used in project-based learning (PBL) and in GIS-based projects which involve students, teachers, the school, and the community (Demirci et al., 2011). These approaches operate on the idea that learning is an active, collaborative, and student-centered endeavor, which is essentially constructivist in orientation.

GIS fosters critical thinking and allows students to use and connect real-life data to their communities (Kerski, 2011). In addition, the capability of GIS to develop students' spatial thinking continues to be acknowledged (Henry & Semple, 2012). Although it seems like there is no consensus about its exact definition, spatial thinking is gleaned to be a collection of different skill sets and aptitude (Bednarz & Lee, 2018; Lee & Bednarz, 2012). A more specific type of spatial thinking called geospatial thinking applies these skills within a geographic context, and focuses on problems related to the Earth's surface and within human experience (Baker et al., 2015; Huynh & Sharpe, 2013).

Worldwide, web-based spatial technologies gained popularity since the inception of the World Wide Web in 1991 (Demirci et al., 2013). An example of these web-based geospatial technologies includes virtual globes, such as Google Earth, which have the capacity to project information such as satellite images, elevation data, and other GIS data layers such as man-made features and road networks (Bodzin, 2011). These added features highlight the advantage of virtual globes over printed maps and traditional desktop globes. Furthermore, earlier studies reckoned that GIS and other geospatial technologies may enhance spatial and geospatial thinking (e.g., Bodzin, 2011; Bodzin et al., 2014; Henry & Semple, 2012). Zwartjes and colleagues (2016) also underscored that these tools could also improve students' critical thinking as they allow them to apply their knowledge in scientific inquiry, problem solving, and synthesis.

A number of GIS and other web-based geospatial technologies are generally cost-free and are open access. Over the last few years, virtual globes such as Google Earth have gained prominence due to their simple interface that allows users to explore the planet in an entertaining and interactive manner (Demirci et al., 2013; Ratinen & Keinonen, 2011). Despite not being considered as a true GIS, Google Earth has heightened the interest of both students and teachers (Demirci et al., 2013). Google Earth, in particular, could help in facilitating critical thinking, spatial analytical operations, spatial perception, and spatial ability (Awada & Diab, 2018; Hamdanah et al., 2020; Merç & Ersoy, 2019). The versatility and practicality of using GIS and GIS-based applications in Earth sciences and allied fields are reflected by the number of researches on its integration in the classroom. Riihelä and Mäki (2015) described how a GIS tool aimed to promote spatial thinking among upper secondary students was developed and implemented in Finland. Results of this Finnish study revealed that GIS has the potential to advance multidisciplinary learning (Riihelä & Mäki, 2015). Moreover, GIS and GIS-based tools can also be utilized to improve the teaching of local and global issues while improving the geographic and technological literacy of students. Bodzin (2011) described how geospatial information technology improved the understanding of 8th grade students regarding land use change and their spatial thinking skills associated with the interpretation of aerial and remotely-sensed images. Guertin and Neville (2011) likewise developed a class activity for a middle school science class that integrated Google Earth in discussing the extent of the Deepwater Horizon oil leak (BP oil spill).

The application of web-based GIS applications and geospatial technologies such as virtual globes across all levels of instruction has been noted in previous studies (e.g., Bodzin, 2011; Guertin & Neville, 2011; Marra et al., 2017; Riihelä & Mäki, 2015). GIS and GIS-based applications are also widely used in more advanced studies such as those in the undergraduate and graduate levels. In a study conducted among first-year baccalaureate program students in Utrecht University, Marra and colleagues (2017) explored the use of Google Earth, satellite images, and data elevation models in preparation for a field course. They found out that students expressed positive attitudes towards the use of these tools and that the use of GIS likewise promoted abstract and reflective thinking skills (Marra et al., 2017). The number of subjects for which GIS can be integrated likewise attests to its potential in teaching and learning (Tan & Chen, 2015).

Integrating Web-based Programs in the Philippine K-to-12 Earth Science Curriculum

The implementation of the K to 12 program in the Philippines since the school year 2012-2013 has opened opportunities for greater ICT integration in the classroom. By virtue of Republic Act (R.A.) 10533, otherwise known as the *"Enhanced Basic Education Act of 2013,"* the current basic education curriculum was clustered into three levels: (a) one year in kindergarten, (b) six years in elementary level, and (c) six years in secondary level, with the last two years dedicated for senior high school (R.A. 10533, 2013). These added years in high school aim to prepare graduates with the necessary knowledge and skills that can be applied in further studies, employment, or business. Students may choose from four tracks – (academic, technical-vocational-livelihood, sports, and arts and design) (Ocampo, 2014).

The Earth science course is one of the core subjects of the Science, Technology, Engineering, and Mathematics (STEM) strand of the Academic Track of the Senior High School (SHS) curriculum (Ocampo, 2014). Currently, it consists of learning competencies and performance standards that students are expected to achieve at the end of the course. These learning objectives include the use of maps and diagrams to understand Earth processes such as the formation of folds, faults, rift valleys, and mountain ridges (DepEd, 2013) To achieve this goal, different maps and other geographic representations are needed. Consequently, the existing thrust of the Department of Education (DepEd) emphasizes the need to integrate ICT alongside the different formative assessments and instructional approaches in the delivery of lessons (DepEd, 2016).

However, challenges and hindrances towards the success of assimilating information and communication technology (ICT) and other technologies in education remain, especially in the Philippines. These include the inadequacy of computer resources, uncertainty to implement new technologies, lack of human capital, and poor financial and management support (Dotong et al., 2016). Bonifacio (2013) added to this list the lack of facilities and the absence of leadership skills among educators, the unavailability of Internet connection, and the lukewarm attitude of teachers towards technology integration. Finding free and low-cost resources that can benefit both students and educators may help in addressing these concerns given that ICT integration in education is capital-intensive (Bonifacio, 2013).

Connectedly, Google Earth has gained the interest of educators and learners globally due to its user-friendly interface (Demirci et al., 2013). Several studies (Bodzin, 2011; Demirci et al., 2013; Guertin & Neville, 2011) have shown Google Earth's potential as a classroom instructional tool which supports spatial and critical thinking and awareness of relevant environmental and societal concepts and issues. Aside from Google Earth, another online mapping tool, Google Maps, may also merit a closer look and consideration. Despite their differences, Google Earth and Google Maps share some common characteristics such as the use of satellite imagery, aerial photography, and street views (Lee, 2010) and both have been used as academic research and mapping tools (Dodsworth & Nicholson, 2012). Google Maps' wide audience of almost 1 billion every month (Rijo, 2020), and added features such as a globe view instead of the usual flat view of the planet (Liptak, 2018) furthered its potential as another instructional tool, particularly in Earth science courses. However, literature on its integration in the classroom remains sparse. Thus, the present study hopes to bridge this gap by investigating the perception of senior high school students on the usefulness of Google Maps in their Earth science class. This may also open opportunities for future researchers to examine Google Maps' effectiveness through research, proofing, and evaluation of pedagogical methods.

Framework of the Study

This research explored the possibility of using Google Maps in teaching and understanding specific Earth science concepts and the reception of its utilization among students. Earlier studies have shown that Earth science learning may be improved by geospatially-enabled learning technologies that highlight geographic visualization, scale, representation, and geospatial thinking and reasoning (Bodzin et al., 2014; Bodzin et al., 2015). Specifically, this study explored the use of Google Maps in observing and inferring the possible locations of surface features associated with faults. Faults are usually large-scale fractures in rocks along which movements resulting to earthquakes have occurred (Huggett, 2011). While movements along some faults result to strong earthquakes, other faults, called creeping faults, move in a more gradual manner (Chen & Bürgmann, 2017). Some of the landforms associated with faults include linear valleys, offset streams, fault scarps, and lineaments or any linear feature that is "too precise to have arisen by chance" (Huggett, 2011, p. 133). However, it must be emphasized that aside from map observations, data from onsite investigations and other relevant sources must be considered in determining the location of a fault. For example, Rimando and colleagues (2019) used both onshore and offshore field data to identify a previously unmapped fault in Bohol. Today, aerial photos and technologies such as light detection and ranging or LiDAR further made it easier to acquire elevation data through remote sensing, which can be used to map fault zones and deep-seated landslides (Chen et al., 2015). The current Earth science curriculum outlines 42 learning competencies which include the discussion on "how rocks behave under different types of stress such as compression, pulling apart, and shearing" (S11ES-IId-27) (DepEd, 2013, p.3) and "how the movement of plates leads to the formation of folds, faults, trenches, volcanoes, rift valleys, and mountain ranges". These two learning competencies apply to the chosen topic presented in the session.

However, the use of geospatial technology in K-12 classroom is still limited worldwide (Adaktylou et al., 2018) and despite the increasing influence of virtual globes and other GIS-based applications in teaching, studies describing their application in the Philippines is very limited. Given the increasing trend in the use of web-based applications, it is but expected for educators to explore their application in the classroom.

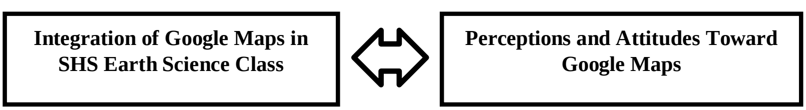

Figure 1. Framework of the Study

The present study hinges around the premise that the use of web-based tools such as Google Maps promotes spatial thinking among learners. The present study posits that Google Maps may be integrated as an instructional tool in teaching and learning specific concepts in Earth science as shown in Figure 1. As students engage in activities utilizing geospatial technologies such as Google Maps, they will most likely develop certain perceptions and attitudes toward appreciating or rejecting their use. Understanding how learners perceive the potential of Google Maps in helping them understand key concepts in Earth science (such as recognizing landscape structures that are usually identified with faults) can give teachers and students the opportunity to discern how to maximize its capability. These perceptions may also provide valuable insights that can help in crafting programs that foster technology in the teaching of geosciences topics in Philippine secondary schools. This inferred relationship is represented by the double-arrow between Google Map's use in Earth science and the students' perceptions and attitudes towards it.

The impact of students' perceptions of their learning process and learning environment has been noted in earlier studies (e.g., Ahmed et al., 2018; Ferreira et al., 2019; Mapuranga et al., 2015). Ahmed and colleagues (2018) observed that among medical students, those who have had a more positive perception of their education performed better in their academics. Studies have also underscored how behaviors of university students can possibly be affected by their perceptions of the factors influencing their academic success (Mapuranga et al., 2015). In a study among Finnish and Brazilian secondary students, Ferreira and colleagues (2019) highlighted the value of listening to students' perceptions about their learning and acknowledged that the students' reflections about their learning situations can help in identifying and developing pedagogical practices. Demirci, Karaburun, and Kılar (2013) concluded that students' motivations and enthusiasm in doing an activity with Google Earth are among the evidences suggesting its effectiveness in helping them visualize the Earth in a geography classroom. Finally, earlier studies also suggest that students' conceptual understanding of science has improved because of Internet-based learning environments (Lee et al., 2011). Hence, as the present study looks into the prospect of Google Maps in an Earth science classroom, it is worth examining how the learners receive it and perceive its use.

Purpose of the Research

This study explored the feasibility of using Google Maps as a tool in teaching a particular topic in senior high school Earth science, and specifically sought to describe students' perception and attitude towards its use in class. The study also aimed to identify the challenges encountered by the students during their activity with Google Maps as well as their suggestions to improve its integration in the classroom.

Methodology

Research Design and Participants

This study employed a descriptive research design. The participants were chosen conveniently among the Grade 11 students enrolled in a STEM track class of a private, sectarian high school in Laguna, Philippines. The class is handled by the teacher-researcher and was composed of 34 students. Prior to senior high school, 30 of the students were enrolled in the same school for junior high while four transferred in the same academic year when this study was conducted.

All necessary clearances and permissions were secured from the school administration before the conduct of this research. The participants were also informed of the research objectives before the questionnaires were distributed. It was explicitly mentioned to the participants that answering the survey is purely voluntary and they may withdraw their responses at any point during the duration of the study. The respondents were assured of anonymity and confidentiality of all information gathered. The survey questionnaire included an explanatory note detailing the above conditions. The questionnaire did not ask of any personally identifiable information to ensure anonymity.

Instruments

The development of instruments and the data gathering procedures in the present study adapted the methods presented in Demirci, Karaburun, and Kılar's (2013) study which examined the use of Google Earth in conducting geography lessons, specifically on the topic of coastal formations. In contrast, this study employed Google Maps in a senior high school Earth science class tackling lessons on faults and other landforms associated with them. Prior to the administration of the self-evaluation form (SEF), an online Google Maps activity (GMA) was done by the students. The GMA is a five-item, researcher-made formative map test intended to gauge the ability of students to recognize landforms, such as valleys and lineaments, that are generally related to faults. The SEF focused on eliciting the students' perception on the usability of Google Maps in Earth science instruction. The questions in the SEF (adapted from Demirci et al., 2013) sought the following information:

(1) Students' prior use of Google Maps and the nature of their usage
(2) Skills that were developed during the Google Maps activity
(3) Challenges that were encountered during the activity
(4) Recommendations to further improve the delivery of the Google Maps exercise
(5) Students' perception of Google Maps' usability in teaching Earth science concepts
(6) Self-evaluation regarding one's attitude towards Google Maps and its impact on individual motivation

The SEF is divided into five parts. This survey questionnaire was approved by the faculty development office of the researcher's home institution. The first part asked for the students' prior use of Google Maps in their other academic subjects. The questions included in this first part of the SEF are shown in Table 1. The second and third sections of the SEF asked for the challenges encountered and suggestion to improve the GMA, respectively. The fourth section of the SEF sought the respondents view on the effectiveness of Google Maps and other GIS-based applications in understanding Earth science. Lastly, the fifth section consisted of an eight-item questionnaire with Cronbach's alpha of .802, which can be assumed to indicate high level of internal consistency. Survey items in the fifth section of the SEF are presented in Table 2. The SEF also included open-ended questions regarding the students' perception of the effectivity of Google Maps in enhancing the discussion of the topic, the challenges that they encountered during the activity, and their recommendations on how this activity can further be improved.

Study Context

Introduction and Orientation to Google Maps

The study used data sourced from the first semester of school year 2018-2019 in two stages: the GMA and the administration of the SEF. Prior to the session, the students were asked to bring their own devices, preferably laptop computers, which can connect to the Internet and can access the Google Maps website (*maps.google.com*). A brief orientation on how to use Google Maps was given at the start of the activity. This orientation discussed the basic features of Google Maps such as navigating the map, zooming in and out, using and changing the map scale (e.g., from meters to feet), and changing the map view (e.g., map, satellite, terrain). After the orientation, the students were instructed to observe Figure 2, identify any landform or pattern on the Earth's surface that they infer are related to faults, and discuss among themselves their observations.

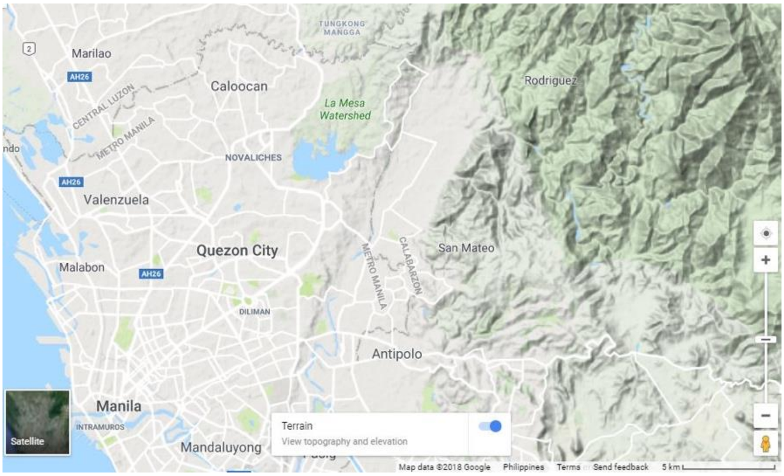

Figure 2. Google Maps image showing the Quezon City-Marikina City-Rizal area (Google, 2018); Map data: Google

Initial Observation with Google Maps

Individual answer sheets for the GMA were then distributed to the students after the discussion and sharing. These answer sheets included four maps corresponding to different areas in the Philippines: (a) Central Luzon, (b) Mindoro Island, (c) Leyte Island, and (d) Lake Mainit in Surigao del Norte. The students were given time to examine each area using Google Maps. In this activity, students were instructed to use the '*Terrain'* view of Google Maps which provides a hill-shaded impression of the area. The goal of this activity is to infer the location and trace five landforms that may be associated with faults (two in Central Luzon, one in Mindoro Island, one in Leyte Island, and one near Lake Mainit). These surface features were previously discussed in class. Aside from identifying these physiographic attributes, the respondents were also encouraged to explore other features of Google Maps on their own. Moreover, it was emphasized among the students that while aerial and/or map observations like the GMA is one of the first steps in tracing the possible location of faults and fault-related landforms, more detailed and precise investigations, such as fieldworks, are required to establish their positions.

Lecture and Post-Lecture Re-observation with Google Maps

After the students have completed answering the activity, a short lecture for about 10 to 15 minutes was given to discuss how linear features or lineaments, as well as fault scarps and ridge valleys may be used to infer the location of faults on the Earth's surface (see Huggett, 2011). The area shown in Figure 1 was re-examined. After a closer inspection, two prominent linear features can be seen in Figure 2. These features correspond to the West Valley Fault and East Valley Fault (of the Marikina Valley Fault System) (Rimando & Knuepfer, 2006). These faults are delineated by the solid and dashed red lines in Figure 3.

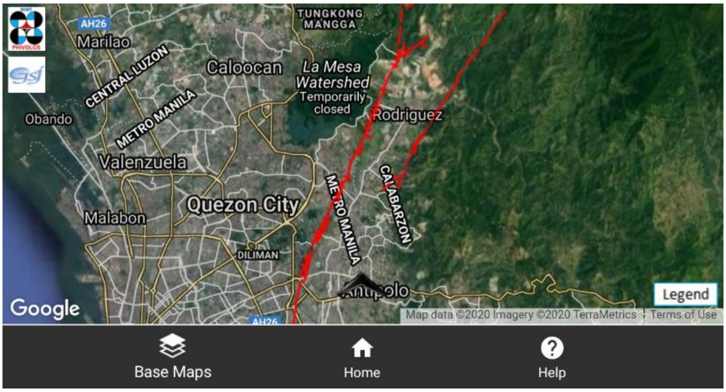

Figure 3. Screenshot of the PHIVOLCS FaultFinder App showing the Valley Fault System (VFS) traced by red solid and dashed lines (Bandibas & PHIVOLCS, 2019); Map data: Google, TerraMetrics *(Copyright TerraMetrics, inc. www.terrametrics.com)*

Using the same procedure, the students were requested to revisit their answers in the pre-lecture stage and were asked to make the necessary changes or adjustments. To distinguish their pre-lecture from their post-lecture answers, the students were directed to signify their answers using a differently colored pen or marks that are distinct from the ones they have used during the pre-lecture phase (e.g., broken or dashed lines). In this activity, a correct answer corresponds to a response which generally follows the traces of the faults in the areas enumerated above. These fault traces can be accessed and seen in the DOST PHIVOLCS FaultFinder website (http://faultfinder.phivolcs.dost.gov.ph/) or its mobile application (Bandibas & PHIVOLCS, 2019). Note that Figure 3 shows the screen capture of the latest version of the FaultFinder app as of April 2020. At the time of the implementation of the online GMA the web app was accessed by the teacher-researcher through the link mentioned above.

Data Collection

The GMA was developed and implemented as a formative activity for a one-hour senior high school Earth science class (n=34). A total of eleven computers were available during the implementation, and the students were asked to form smaller groups consisting of three members each.

Despite the limited number of computers, this setting with students working in smaller groups allowed them to discuss their answers more thoroughly. The administration of the SEF was carried out during the next session.

Data Analysis

The responses in the SEF were examined and hereby presented using descriptive statistics such as means and standard deviations, frequencies, and percentages. It should be noted that the items in the *SEF* were answered using a numerical scale as follows: 5 – Strongly Agree; 4 – Agree; 3 – Neutral; 2 – Disagree; 1 – Strongly Disagree. Emerging themes in the responses to the open-ended questions were identified and presented in the succeeding section.

Results and Discussion

Thirty (30) of the original 34 students answered the questionnaire. Table 1 summarizes the students' responses with respect to their prior experience using Google Maps and the skills they learned during the activity. Majority (97%) of the students mentioned that it was their first time to use Google Maps in any of their academic subjects as shown in Table 1. Nonetheless, all of them were able to use its search function to locate a place which is one of the aims of the online GMA. In this activity, students were asked to navigate the map and look for specific areas in the Philippines. The students were then asked to observe these areas using Google Maps' Terrain. More than 90% of the students were able to do this navigation and switching of map views during the activity.

It can be gleaned, however, that more than half of the class were not able to deduce the coordinates of an area (70%) and use the distance measuring tool of Google Maps (87%). As majority of the students have not used Google Maps in any academic activity before, it might be the case that they too are unfamiliar to its other function aside from the ones discussed in the orientation, which were used in the activity. Furthermore, looking for the coordinates of a point and measuring the distance between two points in Google Maps were not explicitly part of the GMA but were simply hinted by the teachers for students to explore once they are done answering the activity. Interestingly, Pechenkina and

Aeschliman (2017) noticed that students have scarcely and hesitantly used educational technologies particularly when these are new to them. The time allotted for the activity could also have limited the students' chance to further explore the other functions of Google Maps. As one students noted, the activity should "*allow the students to 'play around' with the application to be more accustomed.*" This effect of time on learning was observed by Sadeghi and Dousti (2013) among English as a Foreign Language or EFL students in Iran. In this study, students' grammar learning was found to have increased with the length of exposure to a language learning software. In addition, Darling-Hammond and colleagues (2020) stated that repeated exposure to concepts is a characteristic of an effective inquiry task. Spaced out repeated encounters with materials likewise promote long-term learning (Kang, 2016).

Table 1. Prior use of Google Maps in other subjects and skills learned in the activity (*n*=30)

	Responses in %	
Questions	**Yes**	**No**
Do you have any prior experience of using Google Maps in any of your academic subjects before?	3	97
Were you able to find a place in Google Maps?	100	0
Were you able to change the interface of the map (e.g., from road view to terrain view)?	93	7
Were you able to navigate the map in order to explore the surrounding regions?	97	3
Were you able to determine the coordinates of an area?	30	70
Were you able to measure the distance between two points on the map?	13	87

Table 2 presents the students' perception on the use of Google Maps in their Earth science lesson. In the discussion of these findings, 'strongly agree' and 'agree' are interpreted to connote positive response to the survey item while 'disagree' and 'strongly disagree' are viewed as negative responses. Majority, which is operationally defined here to be more than 50%, of the students reported that they like the GMA and held positive regard to its effect on their perceived understanding of the topic, interest in Earth science, and intent to use Google Maps in future lessons in class.

Table 2. Students' Perceived Usefulness of the *GMA* (*n*=30)

Survey Item	*Responses in %*						**SD**
	SA	**A**	**N**	**D**	**SDis**	**M**[a]	
I liked the Google Maps activity	56.7	33.3	10.0	0.0	0.0	***4.5***	*0.6*
I will try to use Google Maps from now on	6.7	36.7	56.7	0.0	0.0	***3.5***	*0.7*
Exercises like this increase my interest in Earth science	43.3	36.7	20.0	0.0	0.0	***4.3***	*0.7*
The activity helped me understand the topic more	50.0	36.7	13.3	0.0	0.0	***4.4***	*0.8*
The activity allowed me to think critically	23.3	33.3	40.0	3.3	0.0	***3.8***	*0.9*
The activity was entertaining and stimulating	43.3	43.3	13.3	0.0	0.0	***4.3***	*0.7*
The activity sparked my interest in using GIS	13.3	43.3	46.7	0.0	0.0	***3.7***	*0.7*
I can use the knowledge I acquired in this activity in future lessons/class requirements	36.7	46.7	16.7	0.0	0.0	***4.2***	*0.7*

Adapted from Demirci, Karaburun, & Kılar (2013)
SA – strongly agree; A – agree; N – neutral; D – disagree; SDis – strongly disagree
[a] Overall mean was calculated based on the individual ratings of students per criterion; 5.00 is the highest point per criterion

There are several factors that could have contributed to the positive reception of Google Maps by the students. A quick survey of the items in Table 2 may already provide hints to this observed appreciation of Google Maps. For example, almost 87% of the respondents mentioned that the activity was entertaining and stimulating. The positive effect of combining learning and entertainment on students' interest and learning has been noted in previous studies such as that of Putra and Setyaningrum (2018). In their investigation of the effects of an edutainment, or education and entertainment, learning media on mathematics interest and learning among secondary students, Putra and Setyaningrum (2018) noticed in their study that a significant difference between the experimental group who used a smartphone mathematics application and the control group. In the case of GIS and other geospatial technologies such as virtual globes, students may consider them interesting because of the new learning experiences they could present through their interactive capabilities (Bodzin et al., 2014). These virtual globes are easily accessible and can provide imagery (for visual learners) and terrain data (Yu & Gong, 2012). Teachers and students can benefit from web-based GIS such as Google Earth and Google Maps because they can afford them to explore the planet without dealing with the complexity and technicality of other GIS (Jo et al., 2016). In a study that employed Google Earth in a geography classroom, Demirci, Karaburun, and Kılar (2013) surmised that both students and teachers were able to explore the planet more due to the virtual globe's accessibility, ease of use, and geospatial tools. Just like Google Earth and other online geospatial tools, Google Maps is also accessible as it can be used with just a web browser and Internet connection and is interactive with its wide array of views such as satellite, street, and terrain views and functionalities such as voice command and offline viewing of maps (Dove & Hill, 2020). These characteristics render Google Maps a potent candidate as an educational tool, especially in the Earth sciences.

When asked whether Google Maps and other GIS-based applications are useful in understanding concepts in Earth science, 29 students (97%) answered yes. One student chose the option "I cannot decide at this moment" citing the lack of mastery in using Google Maps as justification. Nonetheless, responses to the open-ended questions in the survey corroborate that the interactive and visual nature of Google Maps helped the students in appreciating better the topic discussed. This is reflected in the students' responses quoted below:

> *"It helps us visualize the topic [...]"*
>
> *"It gives an interactive experience for other students to view and explore."*
>
> *"Google Maps provides a bridge between the classroom and the real life. Through Google Maps we may be more appreciative of the lessons taught in Earth science."*

Moreover, the activity sparked the respondents' interest in Earth science as evidenced by the number of respondents (80%) who indicated an affirmative stance to this item in the survey. This finding corroborates with that of Jakab and colleagues (2017) who mentioned that ICT and, in particular, IBL in GIS education increase students' motivation to learn. Delparte and colleagues (2016) also found out that among Native American students, GIS and geovisualization tools may likewise promote geoscience STEM interest. In addition, even in the social sciences, GIS may serve as an effective instructional tool and motivation among students just as what Corrales-Serrano and colleagues (2019) noted among secondary students in geography and history.

While Google Maps' functions are limited when compared to a true GIS, its potential to be used collaboratively and actively in the classroom was shown in this study. In the present study, the students examined different areas in the Philippines through Google Maps and observed them using its *Terrain* view. Students identified landforms that may be associated with faults and discussed among themselves the reasons for labelling these land features as such. Johnson and colleagues (2011) mentioned that student engagement is probably the top advantage of student-centered learning. The GMA, arguably, promoted this learning paradigm as the students themselves tried to make meaning of the data presented to them. They became engaged with the online tool and with their classmates which further cemented the activity's collaborative and student-centered slant. This is encapsulated by the response of a student stating that "*the students are more engaged during the activity; it holds the interest of a learner*."

However, it is also worth noting that more than half (57%) of the students remained neutral when asked if they will continue using Google Maps. Furthermore, 40% and 47% of the students maintained a neutral stance when asked if Google Maps helped them to think critically and sparked their interest in GIS, respectively. As shown in Table 1, 97% of the respondents indicated that the activity was their first time to use Google Maps in an academic subject. Given this unfamiliarity or limited exposure, it might take some time and practice for these students to fully appreciate the value and application of Google Maps in academic and non-academic usage, especially in the midst of other widely used online technologies such as social networking sites. In addition, other factors affecting students' preferences of educational technologies remain undocumented or unexplored despite students' general positive perceptions of them (Pechenkina & Aeschliman, 2017). This could merit a closer look and could be taken up in future investigations.

When asked about the common challenges they encountered during the activity, the students indicated slow Internet connection, unfamiliarity with the application/website, and the difficulty of identifying geologic structures in a map. Students also gave their opinions regarding how the activity can be improved. Some recurring points include the allotment of more time for the activity, increased frequency of similar activities, and more examples and practice that will train them to use Google Maps. Other suggestions include the exploration of landforms even outside of the country and the possibility of showing more images of the areas being explored. The following responses from the students illustrate these insights:

> *"More activities as such please because it makes the lessons more interesting*"

> *"[…] you should allow the students to "play around" with the application to be more accustomed"*

> *"More items as the activity is really interesting"*

Overall, the students registered positive feedbacks regarding the GMA and how it may have improved their understanding of the topic discussed. The respondents in this study moreover indicated that they have had a meaningful application of Google Maps in their lessons in Earth science as supported by their quantitative and qualitative responses to the SEF. These results, however, must be taken with caution given the limited scope of this study in terms of the number of Earth science concept covered and the number of participants.

Conclusion

The potential of geospatial tools such as virtual globes and other web-based GIS as educational tools has been the subject of previous investigations worldwide. However, a quick survey of available literature would suggest that Google Maps, an online mapping platform, has received relatively less attention compared to other GIS-based tools. In the Philippines, the utilization of accessible, cost-efficient, and user-friendly educational technologies such as Google Maps may help in achieving the goals of our current educational frameworks while considering the socio-economic realities of the learners. To provide a baseline for the integration of Google Maps in the classroom, this study aimed to describe its potential as an educational tool in senior high school. An online Google Maps formative activity was developed and implemented to aid in the discussion of a specific topic in an Earth science class. Students sin this class were tasked to use Google Maps' Terrain view to observe and identify landforms that are usually associated with faults, such as lineaments, ridges, and valleys.

Results suggest that majority of the students have tried to answer all the items in this activity. The survey that followed revealed that majority of students had the activity as their first time to use Google Maps in any of their academic subjects. Despite of this limited prior knowledge, they considered the activity to have improved their interest on the subject, their critical thinking skills, and their understanding of the topic. Majority of them also indicated that using Google Maps was entertaining and stimulating. It increased their interest in Earth science, helped them understand the topic better, and encouraged them to use their learning from the Google Maps activity in their future lessons and tasks. These findings suggest that Google Maps as an instructional tool clearly has the potential as an engaging classroom resource.

On the other hand, students signified Internet connection problems, unfamiliarity to Google Maps functions, and difficulty in inferring landforms from maps as some of the hindrances they encountered during the activity. To address these concerns, the students likewise suggested the addition of more examples and longer time allocation for similar Google Maps exercises. With these observations and insights, it appears that the use of Google Maps in teaching Earth science has gained favorable reception from the students and may serve as basis for further investigation of its applicability in the classroom.

Recommendations

Despite the positive outlook offered by the results of this study, readers are cautioned of its limited scope in terms of the topics covered, number of participants, and length of intervention. Future researchers may extend the application of Google Maps in other competencies required in the current senior high school Earth science curriculum. To highlight the global application of Google Maps, others may look into the possibility of using maps and imagery from other parts of the world. Moreover, given the limited number of participants in the present study, future researchers may also consider to extend the coverage of the investigation to include more schools and participants.

In general, teachers are called to embrace new educational tools that will aid in their practice. As facilitators of learning, teachers need to update themselves about online resources like Google Maps and other educational technologies to respond to the changing educational landscape of the 21st century. In view of the present study, teachers are encouraged to avail for themselves of training and other professional activities that will equip them with skills to creatively and efficiently use Google Maps and other geospatial technologies in their instruction. These propositions, however, will not prosper without the proper support from school administrations. Thus, school leaders are likewise enjoined to invest on their ICT infrastructure as well as faculty development programs that will strengthen the expertise of their teachers. Professional development activities which introduce new knowledge and skills such as the use of GIS entail practice and application (Ratinen & Keinonen, 2011). Consequently, teacher education institutions and continuing education providers may look into the possibility of integrating GIS and GIS-based application training in preparing pre-service teachers. This entire process could benefit both students and teachers if the latter knows how to embed proper technologies in their pedagogical approaches.

Finally, Internet connectivity and the availability of computer and other gadgets may raise concerns regarding the practicality of using Google Maps in specific cases. Some students do not have access to Google Maps at home and rely only on other handheld devices such as smartphones. Hence, designing, implementing, and evaluating similar activities using Google Maps in other portable devices such as tablets and smartphones may also be considered by future investigators.

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