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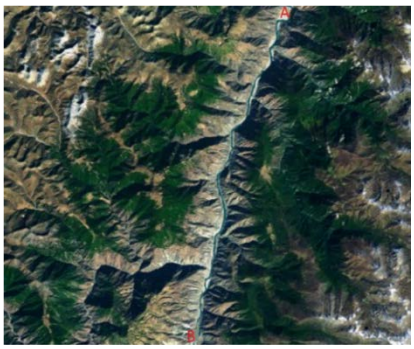
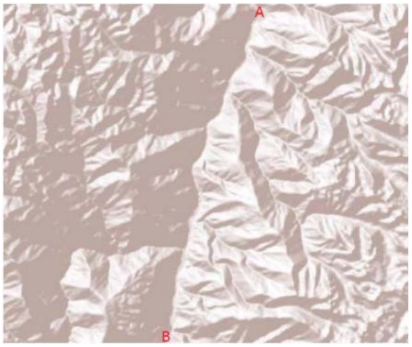
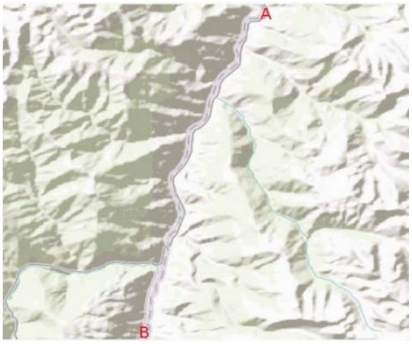
Geographic Information Visualization and Analysis (GIVA)

How aerial photographs, shaded relief maps and shaded relief maps with additional information help secondary school students in identification of spatial phenomena: A case study of Tanzania







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Abstract

The use of photographs and maps has influenced teaching and learning geography methodologies in secondary schools. The main purpose of this master thesis is to compare the effectiveness of aerial photographs, shaded relief maps and shaded relief maps with additional information in identification of spatial phenomena among secondary schools students in Tanzania. Geo-spatial features both in aerial photographs, shaded relief and shaded relief with additional information tested the ability of students to read, recognize and understand them. Participants were also exposed to some technological aspects in order to assess their preference and exposure. A sample of 100 participants (ranged in age from 15-23) with the mean age of 18.75 were involved in the study. The result shows that the performance tested using Analysis of Variance (ANOVA) in identification of spatial phenomena using all three types of maps (aerial photographs, shaded relief maps and shaded relief with additional information were statistically not significant at α =0.05, P=0.1048. The results also show that, participants use more aerial photographs compared to other maps. Almost half of the participants indicated that, they are familiar with Google maps. Computer was also highly favored by the participants to view aerial photographs, shaded relief maps and shaded relief maps with additional information.

K*eywords*: *Aerial photographs, shaded relief maps, shaded relief maps with additional information, technology, teaching and learning Tanzania, secondary school students, spatial phenomena*

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List of acronyms and abbreviations

ANOVA- Analysis of Variance
CD-ROM- Compact Disc, read-only-memory
etc- and other things
e.g- For example
FREQ- Frequent
GIT-Geo Information Technologies
I CT- Information and Communication Technology
i.e- That is
IT- Information Technology
LTM- Long-Term Memory
No- Number
OCCASS-Occasionally
O-LEVEL- Ordinary Level
PBL- problem based learning
P.g- Page
RS- Remote sensing
SDL- Self-directed learning
SRE-shaded relief extra
WM- Working Memory

1 Introduction

Kettun et al (2012) point out that, maps and aerial photographs help to communicate spatial information and these two geo-spatial tools, help to understand the environment even not being into physical contact. David (1976) explains that genuineness shown by aerial photographs and artificial language used by maps make these geo-spatial images to be different.
According to David (1976), the use of symbolic representation on maps, may lead to confusion to most of the students. For example, Liben (2001) shows that young children cannot clearly make association between representational symbols and what is being represented, particularly, when color is used to symbolize the feature. A study by Muehrcke (1974) documents that, maps do not cover the whole truth, in the sense that, few symbolic variables on the map are not enough to represent the reality. Additionally, misinterpretation of cartographic symbols appears to be a common source for map reading errors. In their study, Lloyd & Bunch (2003) state that, children of various ages still face various challenges when trying to acquire information from the map. While Blaut & Stea (1971) state that, informal activities helps young children to learn map skills in early childhood, Anderson & Vasconcellos (1995) point out that much attention is highly needed in order to enable maps become an important tool to communicate spatial information among the children. Real world can be also represented by using shaded relief maps (hill shading). Though, as Rapp et al. (2007) states that, transformation of 2-D map into 2.5-D map may result into difficulty in visualization of information (features). A significant initiatives are required in order to yield positive results by understanding the correctly the features of the real world which has been represented. Symbolic representation of terrain on the map are highly affected by degree of shading on shaded relief maps. This may influence the performance on the identification of spatial features. DeLucia (1972) states that, tone density affect accuracy in reading shaded relief maps. Higher performance is closely related to decrease in to degree of shading. The more the shading, the lower the performance. Kotzil & Doytsher (2003). Comment that, although the relief can be shown clearly on shaded relief maps, they lack artificial details, unlike aerial photographs and images from space. Hurn (2014) state that, the representation of features on the shaded relief maps can be highly influenced by subjectivity of the cartographer and this can lead to the distortion of the map information and unable to convey the message to the final map reader. Cartographic capability can determine how the final map should look like.

Some studies have revealed significant use of aerial photographs among the children. For example Rutland et al. (1993) document some studies conducted in 1970s. These studies found that children below the age of seven have the ability to interpret aerial photograph.
Haynes et al. (2007) evaluated volcanic risks, and find that, aerial photographs are effective Geo-spatial tools to communicate spatial hazard related information. Plester et al. (2003) were interested in the use of photographs among the young children and identified that, young children (ages 4-5) have the potential to understand and use aerial photographs as representations of large real world environments. Children were able to perform many spatial tasks assigned to them successfully (such as feature identification) on account of the information they had learned from photographs, but it was hard for them to perform well geometric related tasks for example distance measurement.

In experimental studies conducted in 1979 and 1983, Filippakopoulou & Nakos (2009) report

that, at small scale level, majority of the students are not able to recognize features between photographs and maps. Another study by Verdi & Kulhavy (2002) found out that, location of features on the map also affects student's ability to recognize them. Symbolic representation of the real world on the maps still a big challenge not only to students of lower levels but also to students of higher levels. Uttal (2000) states that, regular map use may help to identify how children think, and know how they can clearly relate what has been represented and what is available on the physical world.

The aim of this research is to find out how effective aerial photographs, shaded relief maps and shaded relief maps with additional information are in teaching the Geography subject in secondary schools, motivated by the availability of aerial and satellite photos due to technological developments in recent decades. A case study was conducted in Tanzania, (East Africa) where some areas are still to be cartographically mapped, but aerial photographs and satellite images are, in principle, available. Tanzanian secondary school students were involved in the study, whereby a classroom-based experiment was used to collect data in which subjects were asked to answer some questions on a sheet of paper. There are two main reasons which motivated us to conduct this study in Tanzania. First of all, only few studies regarding geographic literacy in Tanzania are available (and one example we could find indicated a fairly low geographic literacy levels); and our study may contribute to the geographic literacy studies. Thus, help in understanding and eventually help the education system. Secondly, we were also motivated by the fact, that in principle, people (teachers and students) can have access to satellite and aerial imagery, but the same cannot be said for all regions in the country for cartographic maps. If photographs facilitate learning geographic concepts in a similar efficiency, then this can allow designing the syllabus accordingly. This study has been structured as follows. Firstly we present the research questions, then review of state-of-the-art, followed by the research methodology. The findings and discussions are discussed in the following section. We conclude the study with a summary of findings, limitation of the study and future research directions, and at the end we list references and appendices used in this work.

1.1 Research questions

This study will determine the accuracy of participants in identification of spatial features when exposed to aerial photographs, shaded relief maps and shaded relief maps with additional information. The following specific research questions will be answered within the frame of the study.

1.1.1 Do students perform better with aerial photographs, shaded relief maps or shaded relief maps with additional information (accuracy) when identifying spatial phenomena?

This question aims to understand if participants perform better at aerial photographs or tested maps when trying to identify given spatial phenomena. Answers might vary from participant to participant depending on the individual cognitive capabilities or other factors like exposure. Cognitive skills are very important in solving the problems. For example, McMahon (2006)

states that students study what they think they will be tested on. The author continues that, the assessment identifies what and how students learn more than the curriculum does. The author also add that, if the test does not reflect the objectives, this will result in inappropriate surface learning and skills and knowledge will not be absorbed and comprehended in a proper way. Apart from school environment to support academic achievement of the student, family influence also plays an important role in achievement motivation to a child in school-related tasks. Parents and other family members could influence the academic achievement of the child directly or indirectly. This depends on how family members are committed in educational matters and support for the academic successful of the child. Parental influence on children academic matters strongly encourages the academic performance among the children. Parents who have low influence on children academic matters, the academic performance might not be as good as for the educational committed families. Parents for example, should make sure that they provide their children with all necessary basic needs for studies, giving them enough time for recreational activities like sports, and allow them to make revision of what they have learnt at school. There must be also parent-teacher communication in order to make a thorough academic follow–up of the child. Schunk (1996) points out that, academic achievement motivation are highly influenced by a particular home of a child. The parental pressure plays a significant role in academic achievement of a child. Schunk (1996) concludes that, parental behaviors might encourage the child to achieve her/his academic goals, though this can also confuse the child due to mult-behavirol life style which could be shown by the parents. From the author, we can say that academic performance of children is highly supported by their parents. Similarly, teachers and other important people (with influence to child's life) play a great role in academic performance of children.

1.1.2 Do students find it easier to identify spatial phenomena in aerial photographs, shaded relief maps or in shaded relief maps with additional information?

The question aims to find out the degree of difficulty when using aerial photographs and maps (shaded relief maps and shaded relief maps with additional information) to identify spatial phenomena. Through this question I will be able to understand whether the question has enough information or not, and also to know if the language was clear to the participants.

1.1.3 Which media do students prefer to view aerial photographs, shaded relief maps or shaded relief maps with additional information when identifying spatial phenomena?

We are also interested to know to what extent students do prefer the use of these media when learning spatial phenomena. Their preference will help to tell what is more familiar to them and what is not familiar to them. Also to know which media is being highly favored as far as learning spatial features is concerned

1.1.4 How do students adapt to the changing technology to learn aerial photographs, shaded relief maps and shaded relief maps with additional information as far as spatial phenomena are concerned?

We want to know how Tanzanian Secondary school students go about technological changes in this world of science and technology. In their study, Kessy et al. (2006) points out that, Information and Communication Technology (ICT) is essential for getting new information, and very supportive as a source material. Although the use of ICT is very important in various sectors including education, in most of the developing countries, the implementation of ICT in schools still faces challenges. Tanzania in particular has the problem of inadequate supply of electricity, especially in rural areas. Electricity services are concentrated in urban areas while most of the rural areas have no access to electricity. Internet access still limited in most of the learning institutions. Additionally, the authors state that, cultural perceptions also affects the use of ICT learning environment. People perceive that technology is just for developed countries and has nothing to do with them. This perception, implies that, they are not ready to learn new technologies. Mambo (2001) documents that, Tanzania being one of the developing countries, has been experiencing gradual growth of information technology. The Information Technology policy in Tanzania is still not clear and have not been fully worked on.

Tedre & Kamppuri (2009) state that, development of Information Technology (IT) education in developing countries still face some substantial challenges such as, professionalism in IT, facilities and financial status.

Since the publication of these literature, some years have passed. We hope to find out new perception, views and motivation about technology. For example nowadays people can access information through their mobile phones. Therefore we expect to get different results.

2. State-of-the-art

In education settings, spatial phenomena are common in teaching and learning, as they are representation of real objects available in our surroundings. Aerial photographs and maps enhance the display of natural and man-made features, as they are being represented on these media and hence encourage spatial skills among the students. This part will describe in detail the following:

Firstly I will present the notion of spatial abilities and thinking in relation to teaching and learning. Spatial feature identification in both aerial photographs and maps will also be presented followed by the notion of shaded relief maps. Then the notion of teaching and learning will be presented particularly on problem-based aspects. Lastly, role of technology in teaching and learning, together with other related technology will be presented.

2. 1 Spatial abilities and spatial thinking

In the review by Hegarty & Waller (2005), spatial ability is described as the ability to represent and process spatial information. The authors add that, spatial abilities varies among individuals. The study of spatial abilities goes as far back as to the 20th century, whereby tests were used to predict academic and technical matters. The National Research Council (NRC) reports "learning to think spatially", defined spatial thinking as a constructive combination of three elements: *concepts of space, tools of representation*, and *processes of reasoning* (NRC, 2006: 12). The report recommends the priority of spatial literacy and the integration of spatial learning in the K-12 curriculum in the United States in order to facilitate the spatial skills and knowledge among the students.

Golledge et al. (2007) explain that, proper and organized language play a significant role to learn geo-spatial concepts. Environmental knowledge and skills can easily be comprehended if the language is learned properly and also one should be exposed to numerous examples as far as geo-spatial skills are concerned. Additionally, Golledge (2002) acknowledges that geography discipline and spatial thinking are inseparable things. Kosslyn & Koenig (1992) (as cited in NRC, 2006**)** add adaptability capability of a person may lead to proper use of images. Retrieval of information from physical environments experiences may help to effectively generate and use of images. NRC (2006) identifies that, the application of simple technology helps students to learn spatial skills and simple technology on the other hand, act as bridge to learn high technology where by a student can be exposed to more complicated spatial tasks.

NRC (2006) provides some characteristics of a spatially literate students such as, to act spatially, to put into practice spatial thinking, to be conversant with spatial concepts and representation, to assess the worth of spatial data with respect to their originality in order to determine accuracy and reliability and use data for solution of problems with strong and critical argument. Jirout & Newcombe (2014: 89) comment that, "spatial learning is an educationally important cognitive domain. For young children for example, informal activities such as playing with blocks, puzzles and maze can support the development of spatial thinking"
Kurtz (2006: 33) provides that "visual perception may be thought of as a cognitive component

of interpreting visual stimuli or more simply understanding what is seen. Visual perception involves the ability to mentally manipulate visual information as needed to solve problems and to take actions in response to environmental demands. Children with problems affecting visual perception have difficulty recognizing, remembering and organizing visual images necessary to understand the written and pictorial symbols that are used for learning".

The study involves spatial capabilities in order to identify spatial features on the geo-spatial tools used to present them. Visual stimuli (aerial photographs, shaded relief maps and shaded relief maps with additional information) with associated visual variables, such as size, color, shadows play an important role in visual perception among the participants when identifying spatial phenomena from a given map. The information available on a given map, may help or not help the participants to perform the given task. Successful attempt on the study tasks depend much on students' prior knowledge and experiences as far as spatial features identification are concerned. Exposure to various spatial tasks is useful in order to solve successfully spatial tasks on this study.

2. 2 Spatial feature identification in aerial photographs and maps

Morgan et al (2010) define aerial photography as photos which are taken by using satellites or space cameras which are placed in high focal points. According to the authors, feature identification in aerial photographs are highly influenced by (i) *tone* or *color*; which is supposed to be applied differently for easy feature recognition. (ii) *shape*, which helps to identify man-made features (iii) *size* which is important for both cultural, natural and ecological identification with their corresponding relative and absolute sizes (iv) t*exture*; which helps to categorize features based on smoothness and roughness, (v) s*hadow*; shadows may assist in identification by providing information about a perspective view or a location of the feature.

Verdi & Kulhavy (2002) state that, a combination of organized spatial things and geographic maps are frequently used as teaching aids in schools from early childhood through higher education. Teachers can connect to their students in remote places with the aid of maps. The authors continue that the student's ability to recall past occurrences depends on the feature available on the map. Thus meaning learning is said to be achieved with such an action. The relevance of past knowledge to feature information is important. Authors claim that learning maps can also be influenced by individual differences among the learners.

Weeden (1997) (as cited in Wiegand, 1999) suggests that children should be able to make a clear differentiation between features available on the map and the objects available on the physical environment. They should be able to make maps which are capable of communicating effectively by meand of the representational symbols on the map, and be able to make a clear interpretation of the information available on the map by using prior knowledge. Thorndyke & Stasz, (1980) point out that, maps help to give explicit and implicit information about various phenomena. Explicitly, we are able to know the visual variables (shape and location) of the object and implicitly, we are able to communicate distant places.

Prior spatial knowledge plays a significant role to understand basic map skills. Spatial capability starts in early childhood. This is highly influenced by day-to-day activities which a particular child is exposed to. Ottosson, (1988) asserts that, at an infant age, a child is aware of some spatial relations. For example infants as young as 6 months can be attracted to the occurrence of interesting small events in a given space. Infants are able to recall where an object was previously, though the location may no longer be visible at a current position. Wiegand (1999) states that map interpretation involves referring to prior geographical knowledge. Jirout & Newcombe (2014) document that, large scale spaces may determine the choice of map when solving problems. Appreciation of the difference between the representation and the real world plays a significant role. The authors add that, proficiency and relevant cognitive capability of children may lead to perform successfully spatial related tasks without consuming much time. Incapability to use maps may lead them to the alternative solution. Therefore it is very important to carefully select which information should be provided by maps in order to enable the children to be effective map users. In his report, Schunk (1996) talks about spatial representation and its related issues. He refers to mental imagery as the “representation of visual/spatial knowledge”. Spatial knowledge involves physical properties of the objects or events represented. The perceived visual stimuli is initially stored in the sensory register and then passed to the working memory (WM) where some of the physical characteristics of the stimulus are stored. Although, representation of spatial knowledge is done by mental imagery, still the real world and the representational images are not clear, and this issue still not fully addressed.

Our study has involved identification of some physical features (spatial phenomena). Aerial photographs and maps (shaded relief and shaded relief maps with additional information) have been used as geo-spatial tools for feature identification. Aerial photographs and maps have been used for a long time to visualize spatial phenomena in Tanzanian secondary schools. The use of these tools aerial photographs and maps for feature representation is an issue since aerial photographs represent the genuine feature, but maps use representational symbols to visualize the physical world. Gravity of performance depends on how clear the concept is to the students. We can’t specifically say that, aerial photographs perform better than maps or maps perform better than aerial photographs in terrain visualization. This is highly influenced by students’ spatial skills capabilities and familiarity to use these geo-spatial tools.

2. 3 Shaded relief maps

Horn (1981) defines shaded relief as the technique of using light and shade in pictorial representation of 2.5 dimensional shapes. The technique involves the transformation of 2-D to 2.5 D perspective of physical features. The technique is traced as far back as many years. The author provides an example of Leonardo da Vinci who put it to good effect in his map of Toscano, drawn in 1502 and 1503, that contained oblique shaded views of forms illuminated from the left. Wood cuts of the area around Zurich, Switzerland drawn half a century later by Murer used shaded side view as well. The author adds that shaded maps are most useful when the map reader has no much time and suggested for small-scale maps.
Areas face directly the light are not shaded while areas away from light are shaded. (Slocum et al. 2000). Yoel (1967) states that shaded relief maps apply more generalized information, whereby the information of the map is reduced. Shades provides a feel of continuous surface

with the presence of value for every particular point on the earth's surface. Kennely (2008) found in his study that, hill shading facilitated visibility of drainage pattern on all volcanic areas. In the same study, areas with strong light, physical features like canyons could easily be observed.

Like other types of questions posed in this study, shaded relief maps have also been based on identification of some spatial phenomena, so as to know to what extent students are familiar with these types of maps when required to perform similar tasks. The assessment will be on the basis of the accuracy. Hill shading share more or less the same degree of complexity with aerial photographs when used to visualize spatial phenomena. These two geo-spatial tools have been used in Tanzanian secondary schools to communicate spatial features. Of course all questions are part of their curriculum and basically the assessment will focus on what they have already learned. As Roediger & Karpicke (2006) comment that, in educational settings, tests are used as instrument for assessing the academic achievement of a student. Normally students are assessed from what they have covered through learning. Tests for assessment helps to discover if a student has achieved properly the content and address some academic related issues in order to maximize the skills and knowledge of a student. JO & Berdinaz (2014) propose that, a teacher should know that, thinking skills is achieved through teaching and the emphasis should be given on that. A teacher should be aware that, critical thinking and mathematical thinking are part of thinking skills. Spatial thinking being part of the thinking skills, should be promoted at educational institutions and it is the role of the teacher to enhance these skills among the students. Newmann (1990) (as cited in JO & Berdnarz (2014: 200) proposed how a teacher can promote students' thinking capability these ways may include "asking challenging questions and giving challenging tasks rather than requiring mere retrieval of information, carefully evaluating students' explanations and reasons for conclusions, pressing students to consider the validity of evidence and reasoning and to suggest alternative perspectives and encouraging students to generate original and unconventional ideas and solutions to problems for promoting mental flexibility. More importantly, a teacher should be a model of thoughtfulness".
In their study, Gettinger & Seitbert (2002) suggest that, cognitive activities is very important for studying. Time management, personal initiative enhance academic performance. Poorly motivated students may not do well in their studies. Domestic support helps to promote academic activities. Support from family members, for example providing necessities for studies encourages effective studies.

2. 4 Problem-based for teaching and learning

Kansanen (1999:86) defines teaching as an interpersonal, interactive activity, typically involving verbal communication, which is undertaken for the purpose of helping one or more students learn or change the ways in which they can or will behave. Usually we call the activity of a teacher "teaching" and the activity of a pupil or a student "learning". There is mutual relationship between these two words, with their different roles. Kirshner (2006) defines learning as a change in long-term memory. From this definition learning can be

explained as a lifelong process in which an individual is able to acquire skills and knowledge. The process of acquiring skills and knowledge can be done through experience or through being taught. Tokcan (2009) also defines learning as the change of thought, behavior and perception of the person due to his interaction with the environment. According to Schunk (1996) learning is a long-lasting change in behavior, or ability to act in a given fashion, which results from practice or other forms of experience. The author gives some criteria for learning for example *change in behavior* or in the capacity for behavior. In which people learn and are able to do things differently. It is not possible to observe learning directly but changes will indicate that someone has learned. The way people act will help to assess learning. Also *learning endures over time,* this means that, learning cannot exist forever due to some factors like forgetting.

(Rogers, 1969; Rogers & Frieberg, 1994) (as cited in Schunk, 1996) discussed education in his book "*Freedom to Learn"*. Meaningful, experiential learning is applicable to a person, and it is self-oriented activity which personal initiatives plays an important role in order to achieve the desired goals. Motivation for learning is activated intrinsically. Meaningful learning leads the learner to what she/he expects to achieve but meaningless learning does not. It is perceived as meaningful learning because students expect to be shaped and their skills and knowledge will be developed, and thus be able to face challenges and solve problems accordingly. Rogers (1969) believed people are born with traits of learning and are motivated to learn. Learning is not a simple task, a person needs to be highly active in learning. Personal skills and knowledge should well evaluated in order to result into meaningful learning. The author identifies teachers as *facilitators* who create the learning environment and help their students to achieve their goals. As a facilitators, the teacher should make sure that, important resources for learning are available and satisfy the needs of the students. Motivation for learning can be done through a two- way traffic method where a teacher can maximize the freedom potential of the students and create an environment which there is mutual sharing of ideas, opinions, experiences and thoughts. Based on social cognitive theory, Schunk, (1996) states that, learning and the performance of behave are correlated. This relationship involves interactivity among the *persons, behaviors* and *environment*. Bandura (1982a, 1986, 2001) (as cited in Schunk, 1996) discussed human behavior within the context of interactivity among behaviors, environmental variables and personal factors. As indicated in (Figure: 1).

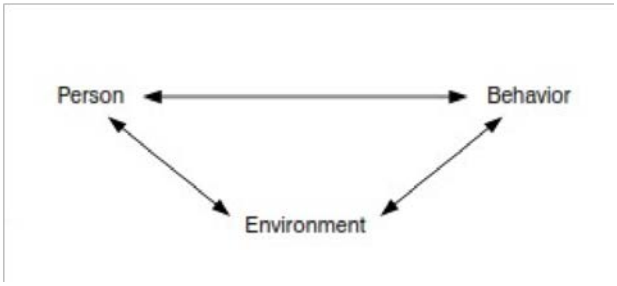


Figure 1: Reciprocal interactions, source Bandura, 1986

Problem-based learning (PBL) has gained popularity among the teaching and learning methods recently. The method is widely used due to its effectiveness. (Yusof et al. 2012). Hmelo-Silver (2004) defines problem-based learning (PBL) as a delivery method in which

students engage fully in problem solving being facilitated by the teacher. Students sometimes in groups are exposed to a problem and work to find answers for the problem while associating their own experiences. Multiple answers are possible in problem based learning The role of the teacher is to be a facilitator in order to guide student learning through the learning cycle as depicted in (Figure 2)

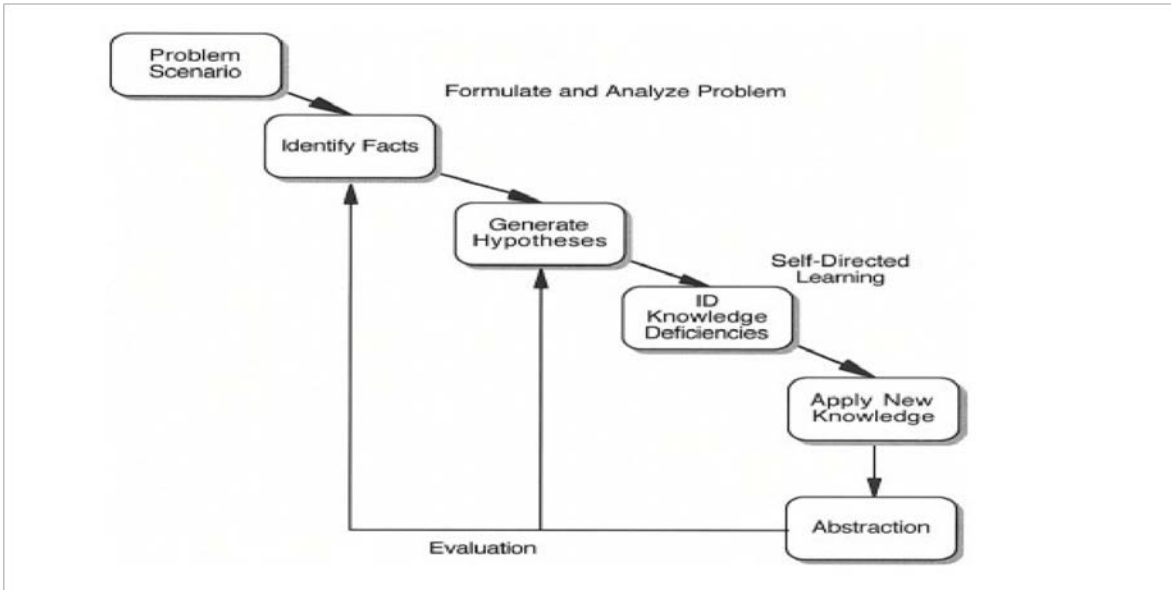


Figure 2: Learning cycle adapted from Hmelo-Silver, 2004

Hmelo-Silver (2004) explains that students have to be exposed to the scenario first where they are able to define the problem with its complexities, think of the plan and how to implement the plan with its associated tools. At this stage, they can think of potential limits which are likely to happen when trying to address the problem. Then, they have to develop hypotheses based on their experiences for a possible solution of the problem. The author identifies knowledge deficiencies as learning issues when trying to solve the problem. During their self-directed learning (SDL), students might face some challenges. The new knowledge gained is evaluated against the proposed solutions (hypotheses) in order to get a clear concept of what has been addressed. Reflection on the abstract knowledge is very important at every final stage of the problem. Sweller (1998) emphasis that problem-solving skills are of paramount importance. Savery (2006) is of the opinion that the approach used by instructors and learners enables them to do research, are able to combine both theory and practice, whilst applying their acquired knowledge and skills in order to produce a lasting solution to the problems at hand. Norman & Schmidt (1992) both imply that those students coming from curriculum that is problem-based tend to be more analytical in approaching the problem. Meanwhile, students coming from conventional curriculum do not possess any independent thinking when it comes to solving matters.

Likewise in geography subject, teaching and learning is said to have been completed if can only equip students with necessary geographical concepts and those concepts have been comprehended well and can be applied when required. As far as spatial features are concerned, students must be empowered to understand them, and be capable of successfully solving spatial related tasks. Students need to understand the related issues

covering all dimensions in depth. Geography teachers must be innovative enough to ascertain that their students interact successfully with a conducive environment, in order to learn geography. Diversification in teaching methodologies is very important in order to maximize the cognitive capability of the students, and hence achieve the desired goals. The teacher should not always be the “giver” (spoon feeding), academic communication should be encouraged in such a way that both sides (teacher and students) are able to share their ideas.

2. 5 The role of technology in teaching and learning

Roschelle et al. (2000) document that, significant increase inevitable educational demands and change of technology have forced educational institutions to change the way of thinking and plans in order to make sure that students successfully utilize academic resources with respect to these waves of changes. This has drastically affected the traditional way of teaching (blackboards and text books). Research indicates that computer technology supports learning. Roschelle et al. (2000) continue to state that, the application of new technology has facilitated and simplified the access of learning content and this has some positive results. Although the use of new technology has come with positive impacts on learning, still there are some issues on generalization of these positive results. Technology is to some extent still a challenge for full utilization in academic institutions.

Svingen (1994) states that, complexity interaction between old technology and new technology has come with new ways how geography subject should be taught. These technological innovations have been seen as inevitable and therefore to be incorporated in the learning curriculum so as to update teachers and students. Wentz et al. (1999) add that computers have become one of the popular instructional media for teaching some basic concepts in geography. The delivery of instructions using computers is useful as helps to supplement to monotonous ways of teaching (books and boards). On the other hand, Sutherland et al. (2004) report that the effective use of Information and Communication Technology (ICT) facilitates learning and promotes teaching skills among teachers. In geography, for instance, John & Sutherland (2004) provide that the effective use of ICT with associated technologies help to learn geography in a scientific way. John & Sutherland describe the ‘Digital Earth’ idea, with the application of internet have exposed children to various matters in the world and developed their new way of thinking. However, the application of ICT for pedagogical matters not necessary simplifies the learning process, in some cases it may be hard to use these technologies. Therefore there is a need to make sure that there is appropriate use of these technologies.

Another important technology which promotes the teaching and learning is the use of internet in academic institutions. The wide spread of internet technology has to a great extent enhanced and simplified the accessibility of teaching and learning materials. Ingram et al. (2000) document that, the use of internet technology has significantly influenced human communication, as well as teaching and learning process**,** for example, the authors add, that through chat programs, learners are able to exchange information and ideas of various subjects. Livingstone & Bober (2004) state that now days, the internet has enabled the young people to communicate for example using e-mail or instant messages. The authors also state that, the young people perceive the internet as something which exposes them to new way

of thinking and maximize their learning potentials, despite being novice to this technology. However, a caution is given by the authors that, although the internet plays a significant role to support the learning process, still the access of information has some problems. The authors identify one major challenge which young children may face when using the internet, which is *searching web*, from this challenge, proper guidance is required in order to enable students access contents which are relevant to their learning capabilities and this will enhance effective learning since students will not be lost in the technology. Proper internet related skills are very important for the effective use of the internet. Students should be able to distinguish which information is important for them and which is not important, and where the relevant information can be obtained. Cattagni & Westat (2001) add that, due to heterogeneity of the information available on the internet, there is a possibility of students to access inappropriate material. Parents and teachers should play their role to make sure a student access the right contents as far as academic matters are concerned. The authors also suggest that, in order to make students make full use of internet and access various material, it is very important that the internet is made accessible outside of school hours, which will actually enable students who had no opportunity to access internet at school use this resource for example at home for school-related activities such as home work.

In our study, we have involved some technological aspects in order to find out to what extent the students are exposed to the technology. Since the use of the existing technology students are able to more explore the world beyond the boundaries and learn more about the external world. There are various media which students can access to learn about the external world and hence enhance their geographical knowledge. For example the availability of Google Earth, is a potential to expand geographical knowledge. NRC (2006) reports that Google Earth is a learning technology which enable the students to dynamically explore and navigate the earth due to its interactive capability. The technology connects students to various spatial matters around the world. Tools like virtual globes and Remote Sensing (RS) satellite imagery, help to promote and support spatial thinking.

3 Research Methodology

3. 1 Research problem

The research problem for this study is how aerial photographs, shaded relief maps and shaded relief maps with additional information help secondary school students in the identification of spatial phenomena.

3. 2 Participants

Participants were 100 Tanzanian ordinary level (O-level) secondary school students from Mwanakianga and Ihala secondary schools. Participants ranged in age from 15-23 with the mean age of 18.75. Majority of the participants were boys (72%) and (28%) were girls. Also, majority of the participants (76%) were form four (fourth grade) students and (24%) were form three (third grade) students. (73%) had no color problems while (22%) indicated as having problems with color vision and while (5%) indicated nothing. A non-random (purposive sampling) was used to draw a sample for this study. The participants were selected purposely because the experimental questions were from the topics which are taught in either form three (third grade) or in form four (fourth grade) according to the Tanzanian secondary schools ordinary level geography syllabus. Drinks and cookies motivated the participants

3. 3 Material for the experiment

The source of 21 images used in this study was from natural earth data (http://www.naturalearthdata.com/) at the medium scale of 1:50m except for three images. The printing was done by using SHARP MX-5112N PS digital printer and sheets for the experiment were colored printed. Scale of the images were 33% X33% (Figure 3) both pencils and erasers were also bought in order to enable the participants to answer the questions.

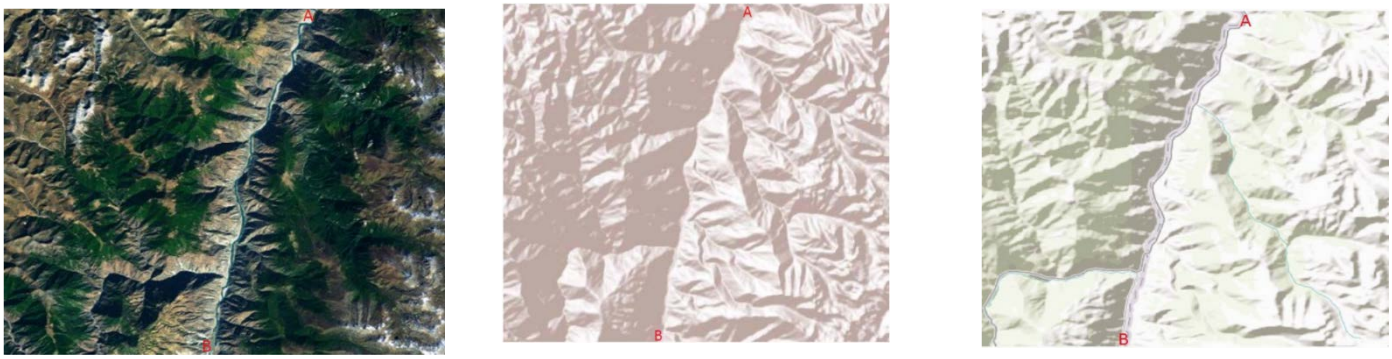


Figure 3: Screen shot of an example of aerial photograph (left), an example of shaded relief maps (middle), and an example of shaded relief maps with additional information (right) used in this study.

3. 4 Procedures

The experiment materials were mailed to Tanzania through postal services in April 2014 and the experiment took place in May 2014 and the materials were mailed back in July 2014. The participants seated in the classroom (classroom based experiment), and all subjects had a chance to answer all questions (within subjects design). According to Martin (2008) the major advantage of within subject experiment is that, variability due to individual differences is minimized. The teacher had to sign the printed version of the consent forms (appendix pg.43) on behalf of the students.

The teacher arranged the participants into their respective seats in the experiment room. The experiment room was big enough to accommodate 50 participants. The experiment was divided into four parts, experiment part 1 (see appendix pg. 48), part 2 which is world map national boundaries (see appendix pg.63), part 3 which is water level task (see appendix pg.64) and part 4 which is about Questionnaire (see appendix pg.65). The teacher gave them document labeled part 1 and read the instructions (see appendix pg.47) to participants loudly briefing some important information about the study. Participants were informed that communication among the participants was not allowed during the experiment and participants were told this could lead to the exclusion from the study. In case of any problem, participants were told to raise up hands in hands in order to be helped by the teacher. Participants were told not to sign in their name and treatment of their responses would be held confidentially. The study was voluntary, and participants were told to withdraw from the study if they are not comfortable. Participants were also asked to keep the pencil after the experiment. Having given the participants important information, the teacher allowed them to start the experiment (Time allowed was 25 minutes, for part 1). Participants were supposed to look at the figure carefully and choose the correct answer from the five option for each question by putting a tick (√) using a pencil in the box provided on the right hand side. If the participant didn't know the answer, she/he was asked to choose "I don't know". Having answered the main question, participants were also asked to indicate degree of difficulty for each question .This question was placed immediately below after the main question. The question represents the self-rated difficulty to complete the main task. The participants answered on a Likert scale from *1: very difficult* to *5: very easy.* Participants were also asked to indicate the rate of difficulty for each questions based on the scale of rating; *1-language was difficult, 2-too much information on the map, 3- too little information on the map and 4-not familiar with the map.* The participants were allowed to indicate more than one option as it seemed reasonable to them. Additionally, participants were also asked to give other extra reasons to state to what extent the attempted question was seen difficult to them.

When part 1 was finished, the teacher repeated procedure for part 2 (Time allowed was 10 minutes). Part 2 experiment was about identification and labelling of world geographic countries with respect to their continents. When part 2 was finished, participants were given document labelled part 3 (Time allowed was 5 minutes). This part of the study was about water level identification task where participants were asked to label the correct water level with respect to the tilted angle. When part 3 was completed, participants were given document labelled part 4 (Time allowed was 5 minutes). Part 4 of the experiment was designed to collect participant's background information. Background questions asked participants to identify their gender (male/female), age and form (grade of study). The part also described what participants were doing in the study, i.e. identification three types of

maps which have been used in the study. This part also asked participants' familiarity with aerial photographs, shaded relief maps and shaded relief maps with additional information. The second part asked about technological aspects. However, the experiments part 2 and part 3 have not been included in the analysis of the results. We collected data as a backup for the main experiment, in case we could find that the feedback from the responses in the main experiment could not meet our needs, since these two parts (part 2 and part 3) involved also spatial aspects. So the analysis involved only part 1 and part 4. Teachers were asked to stay in the room during the whole time of the experiment, so that they could help the participants in case they have problems. Also teachers were asked *not to* give the participants correct answer. Food or drinks were supposed to be handled carefully in the experiment room. Once the participants completed their tasks, were supposed to leave the filled documents on the table and be collected by the teacher. If a participants could finish earlier than 30 minutes were asked to stay in the experiment room until others also finish.

At the end of the session, the teacher announced that we would like to thank them for their participation and receive our best regards from Switzerland. Participants were asked to provide their contact details (e-mail or home address) on the feedback request form (appendix pg. 68) if they would like to hear about the results of the study. Once the experiment was complete, the teacher was asked to make a photocopy (or scan, if possible) of every answer sheet and keep them. If they had to pay for this, they were asked to keep a receipt and send us a copy of the receipt, for reimbursement. Teachers were asked to send back the original answer sheets, signed consent form and the feedback request list to us in a sealed envelope by registered post**.**

3. 5 Variables

The experiment had the following variables; Independent variables; aerial photographs, shaded relief maps and shaded relief maps with additional information (both printed). Dependent variables, being task accuracy (recognizing spatial phenomena), confidence questionnaire to obtain information on their preferences, map use experience and technology exposure (appendix pg. 62)

3. 6 Arrangement of the experimental questions

The study involved three map types which are aerial photographs, shaded relief maps and shaded relief maps with additional information. The order of map types were mixed so that participants do not end up with doing better with one type of map. Therefore, questions were randomized in order to make sure that the participants do not have clue to answers of the rest of the questions (Table 1, Table 2 and Table 3) below show randomization of the question. Question numbers were not assigned to questions.

Question 1-8	Question 9-16	Question 17-24
A	B	C
B	C	A
C	A	B
C	B	A
A	B	C
B	C	A
C	A	B
C	B	A

Table 1: Showing block 1 randomization of questions

Question 1-8	Question 9-16	Question 17-24
C	A	B
A	B	C
C	C	B
A	B	A
B	C	A
C	A	B
A	C	C
B	A	B

Table 2: Showing block 2 randomization of questions

Question 1-8	Question 9-16	Question 17-24
B	C	A
C	A	B
A	B	C
B	A	B
A	B	C
B	C	A
C	B	C
B	A	A

Table 3: Showing block 3 randomization of questions

4 Results

The results of the three maps (aerial photograph, shaded relief maps and shaded relief maps with additional information) have been summarized in the ANOVA (Table 4) below. The analysis based on the task accuracy for the three types of maps. Analysis of variance (ANOVA) with the interaction between the three maps, was applied to all maps on the basis of correctness of each type of question. The ANOVA table shows that, the interaction between the three maps (aerial photographs, shaded relief and shaded relief with additional information), gives the results which are not statistically significant. In this experiment, α =0.05, F (2, 2.273) = 5.853, P=0.1048.

Condition	N	Mean	S.E.M	Sum squares	Rank Sum	RS^2/N	
Correct satellite	100	2.69	0.148	941	13785	1900262.25	
Correct shaded	100	3.15	0.162	1253	15960	2547216	
Correct SRE	100	3.05	0.17	1217	15405	2373140.25	
Total	300	2.963	0.093	3411	45150	6820618.5	
Tukey HSD (0.05)	100	0.531					
Tukey HSD (0.01)	100	0.661					
ANOVA Table	Effect of condition						
Source	SS	df	MS	F	P>F	Krusskall-Wallis	P>KW
Between	11.707	2	5.853	2.273	0.1048	3.394	0.1832
Within	764.89	297	2.575				
Total	776.597	299	2.597				

Table 4: Summary of ANOVA results of correct responses for satellite, shaded relief and shaded relief with additional information

A breakdown of the correct responses for the three types of maps is shown in the graph below. (Figure 4). From the graph, the mean for aerial photographs is 2.69 (SD=1.482), shaded relief maps has the mean of 3.15 (SD=1.623) and shaded relief with additional information with the mean of 3.05 (SD=1.702)

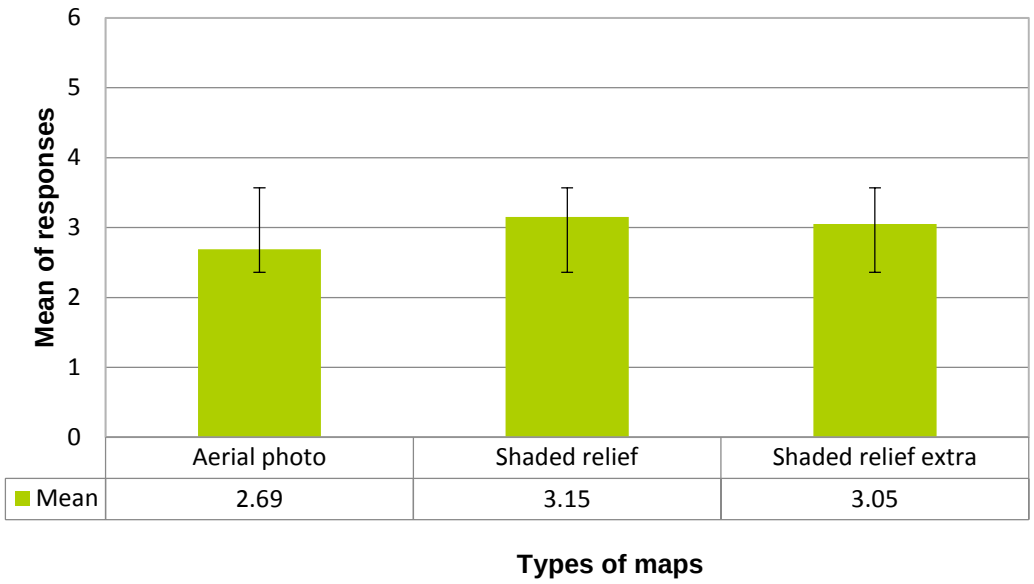


Figure 4: shows the mean of correct responses for aerial photographs, shaded relief maps and shaded relief maps with additional information.

4. 1 Overall correct, incorrect responses

A breakdown of the overall mean for correct, incorrect responses for the three types of maps is shown in (Figure 5). From the graph below, the mean for overall correct responses was 9.57 (SD=3.991) while the mean for incorrect responses was 10.43. (SD=4.473)

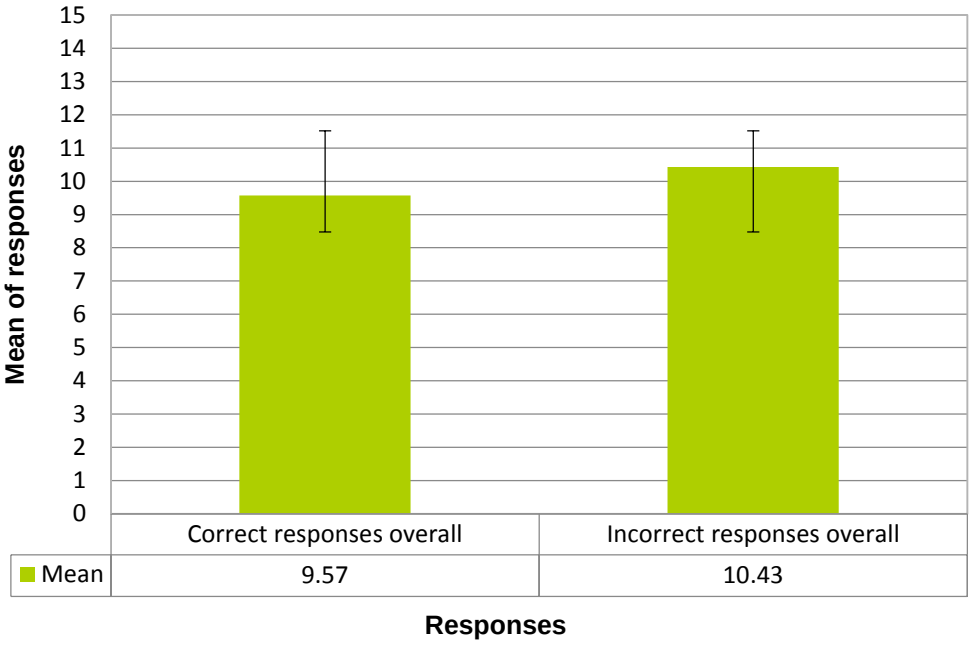


Figure 5: Overall correct responses and incorrect responses

The ANOVA (Table 5) below indicates the results of the four types of spatial features (drainage patterns, river features, physical features and features i.e. valleys) used in the study. The analysis based on how accurately the participants were able to identify them from the geo-spatial tools used to present them. The ANOVA (Table 5) shows that, the interaction between these four geo-spatial features gives the results which are statistically significant. In this experiment, α =0.05, F (3, 4.69) = 11.683, P=0.0031.

Condition	N	Mean	S.E.M	Sum squares	Rank Sum	RS^2/N	
Drainage patterns	100	2.11	0.149	665	18112	3280445.44	
River features	100	2.29	0.18	845	19121.5	3656317.623	
Physical features	100	2.89	0.149	1055	23608	5573376.64	
Features (valleys)	100	2.28	0.151	746	19358.5	3747515.223	
Total	400	2.393	0.08	3311	80200	16257654.925	
Tukey HSD (0.05)	100	0.573					
Tukey HSD (0.01)	100	0.694					
ANOVA Table	Effect of condition						
Source	SS	df	MS	F	P>F	Krusskall-Wallis	P>KW
Between	35.048	3	11.683	4.69	0.0031	13.283	0.0041
Within	986.33	396	2.491				
Total	1021.378	399	2.56				

Table 5: Summary of ANOVA results of correct responses for geo-spatial features

A breakdown of the correct responses based on the four types of spatial features observed on each type of geo-spatial tool are shown in the graph below. (Figure 6). From the graph, the mean for drainage patterns is 2.11 (SD=0.149), mean for river features 2.29 (SD=0.18), mean for physical features is 2.89 (SD=0.151) and mean for features (valleys) is 2.28 (SD=0.08)

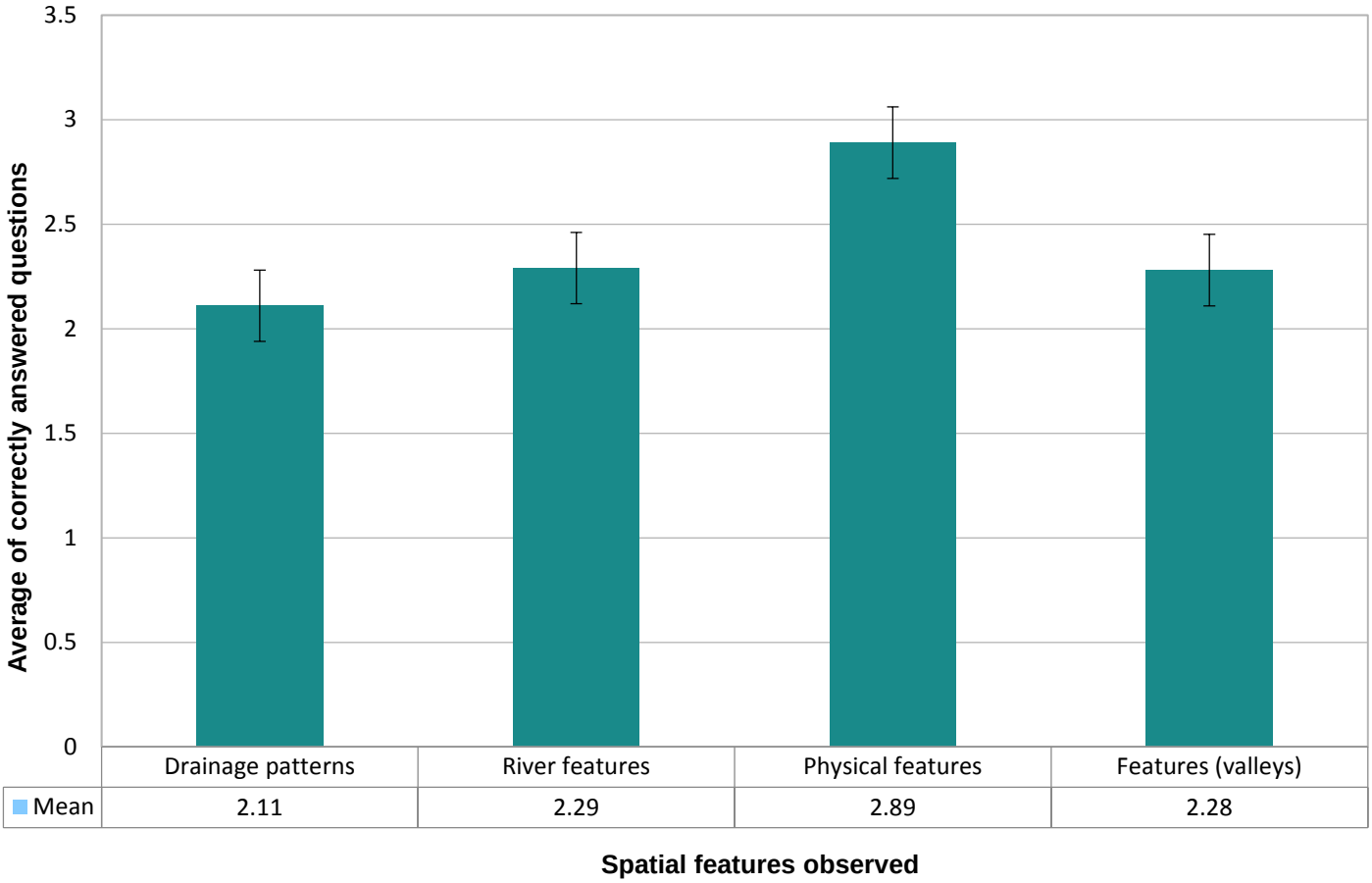


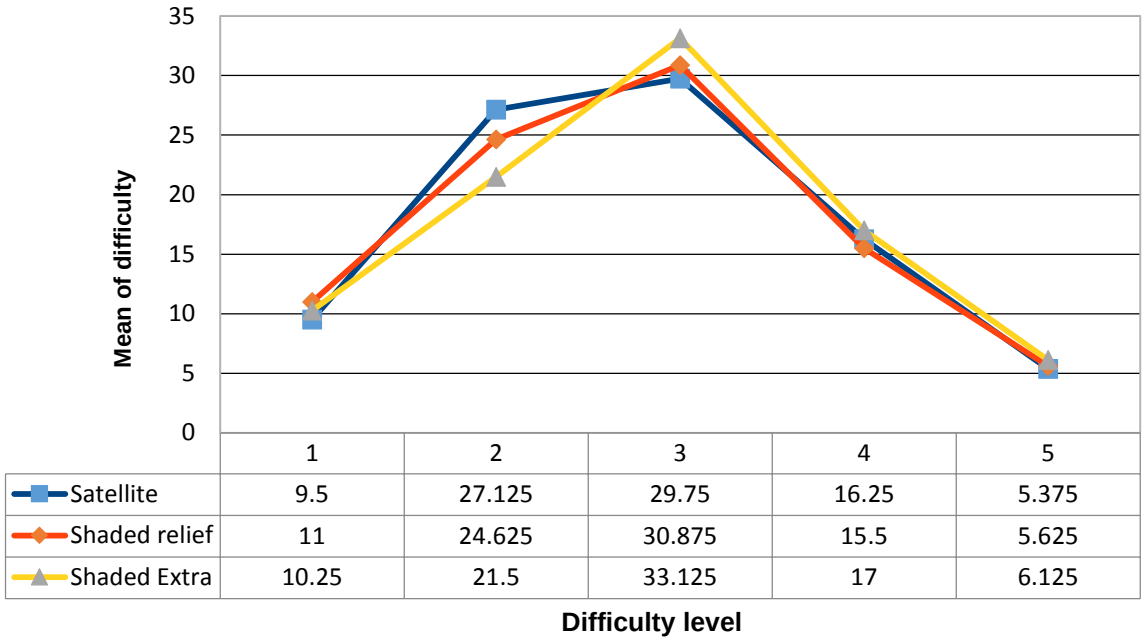
Figure 6: Correct responses from geo-spatial features

4. 2 Difficulty of questions

The participants were asked to indicate degree of difficulty for each question .This question was placed immediately below after the main question. The question represents the self-rated difficulty to complete the main task. The participants answered on a Likert scale (Likert, 1932) from *1: very difficult* to *5: very easy.*
The responses for each question by each participant, with respect to self-rated degree of difficulty is indicated in Figure 7. In the analysis of these questions, *I don't know responses* and *unanswered* questions were not included.

From the graph below (Figure 7), at *very difficult* level, shaded relief maps with additional information had the highest mean (11) followed by shaded relief maps (10.25) and satellite images with the lowest mean (9.5). At *difficult* level, satellite images had the highest mean (27.125), shaded relief maps had a mean of (24.625) and shaded relief maps with additional information with a mean of (21.5). At *moderate* level, shaded relief maps with additional information had the highest mean (33.125) followed by shaded relief maps with a mean of (30.875) and satellite images had the lowest mean (29.75). At *easy* level, shaded relief maps

with additional information had the highest mean (17), while satellite images had a mean of (16.25) and shaded relief maps had the lowest mean (15.5) At *very easy* level, shaded relief maps with additional information had the highest mean (6.125), followed by shaded relief maps with a mean of (5.25) and satellite images had the lowest mean (5.375).



	1	2	3	4	5
Satellite	9.5	27.125	29.75	16.25	5.375
Shaded relief	11	24.625	30.875	15.5	5.625
Shaded Extra	10.25	21.5	33.125	17	6.125

Figure.7: Degree of difficulty rate for every question

Participants were also asked to indicate the rate of difficulty for each questions based on the scale of rating; *1-language was difficult, 2-too much information on the map, 3- too little information on the map and 4- not familiar with the map.* The participants were allowed to indicate more than one option as it seemed reasonable to them. The responses for each type of map is provided as it can be seen clearly in (Table 6) below. The results in this table indicate that, shaded relief map with additional information was highly rated (74) at *language difficult*, followed by shaded relief maps (69) and satellite images were lowly rated (67). At *too much information* level, satellite images were highly rated (159), followed by shaded relief maps (136) and shaded relief maps with additional information (133). At *too little information* on the map level, shaded relief with additional information had the highest rate (196), followed by shaded relief maps (173), and satellite images (162). At *not familiar with the map* level, there were a difference of one among the maps whereby, shaded relief maps were rated (70), followed by shaded relief with additional information (69) and satellite images were rated (68). Some participants indicated more than one reasons and we grouped them as follows; *"language was difficult and too much information levels",* both satellite images and shaded relief maps with additional information were rated (6) and shaded relief maps had (5). *"Language was difficult and too little information on the map",* shaded relief maps had (17) while both satellite images and shaded relief with additional information had the same rating of (13). *"Language was difficult and not familiar with the map"* had (2) ratings only for shaded relief maps with additional information. Some indicated also, *"too much information on the map and not familiar with the map".* At this levels, satellite images had (4) and shaded relief

maps had (1). At *"too little information on the map and not familiar with the map"* levels, only shaded relief maps were rated (2). For *"too much information on the map, too little information on the map and not familiar with the map"* levels, shaded relief maps had (4), followed by shaded relief with additional information (3) and satellite images had (1)

Rates	Satellite	Shaded relief	Shaded relief additional
1	67	69	74
2	159	136	133
3	162	173	196
4	68	70	69
1, 2	6	5	6
1, 3	13	17	13
1, 4	-	-	2
2, 4	4	1	-
3, 4		2	-
2, 3, 4	1	4	3

Table 6 difficulty level based on reasons

***Key**: Table 6: is illustrated as follows: 1-language was difficult, 2- too much information on the map, 3- too little information on the map, 4- not familiar with the map, 1,2-language was difficult and too much information, 1,3 (language was difficult and too little information, 1,4 (language was difficult and not familiar with the map), 2,4(too much information and not familiar with the map), 2,3,4 (too much information, too little information and not familiar with the map*

In additional to rating the degree of difficulty and reasons for difficulty for each question, participants were also asked to give other extra reasons to state to what extent the attempted question was seen difficult to them. The information about difficulty questions is provided in (Table 7) below for some questions

Question number	**Reason**
1	Image not clear, features not clear, not easy to identify the feature
4	Objects not seen clearly
5	Feature not indicated
9	Image is small, the image has no more details
13	Difficult to identify feature, physical features not shown clearly
14	Image not clear, not easy to identify feature, features not clear
16	Difficult to identify feature, not easy to identify feature
17	Image not clear
20	Image not clear, figure is small, figure is not seen clearly, features cannot be seen clearly
22	Not aware of the figure, image not clear, not easy to identify the features
24	Map shows nothing, difficult to identify feature, map shows nothing, not easy to identify the features

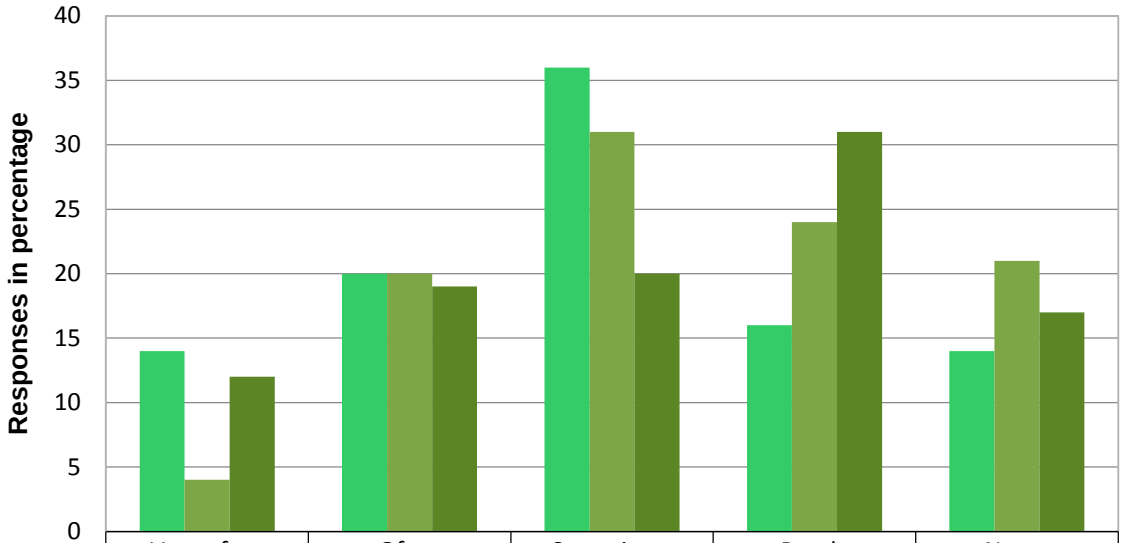
Table 7: Various extra reasons given by the participants on difficulty of the task

4. 3 Questionnaire

In this part, we were interested to explore information about participants' preferences and motivation about aerial photographs, shaded relief maps and shaded relief maps with additional information. Also technological aspects were included.

4. 4 Frequency use of maps.

The participants were asked to indicate how often they use aerial photographs, shaded relief and shaded relief with additional information based on the Likert scale, (self- rated options). The responses in (Figure 8) show that, *very often* option had the following scores; aerial photos (14%), shaded relief (4%), shaded relief with extra additional information (12%), *often* option with the following results; aerial photos (20%), shaded relief (20%) and shaded relief with additional information (19%), *sometimes* option with the following results; aerial photographs (36%), shaded relief (31%) and shaded relief with additional information (20%). *Rarely* option had the following results; aerial photographs (16%)**,** shaded relief (24%) and shaded relief with additional information (31%), and for *never* response; the results are as follows; aerial photographs (14%), shaded relief (21%) and shaded relief with additional information (17%).



	Very often	Often	Sometimes	Rarely	Never
Aerial photo	14	20	36	16	14
Shaded relief	4	20	31	24	21
Shaded relief extra	12	19	20	31	17

Figure 8: responses on how participants frequently use aerial photographs, shaded relief maps and shaded relief maps with additional information

4 .5 Uses of maps outside the school.

Figure 9 below indicates the responses of participants on the uses of aerial photographs, shaded relief and shaded relief maps with additional information outside the school. The responses show that, for *Yes* response, 63% of participants indicated that they use aerial photographs outside the school, 43% showed that they use shaded relief maps with additional information outside the school and 41% indicated that they use shaded relief maps outside the school. For *No* response, 54% showed that they don't use shaded relief maps outside the school, 51% indicated that, they don't use shaded relief maps with additional information outside the school and 33% showed that, they don't use aerial photographs outside the school.

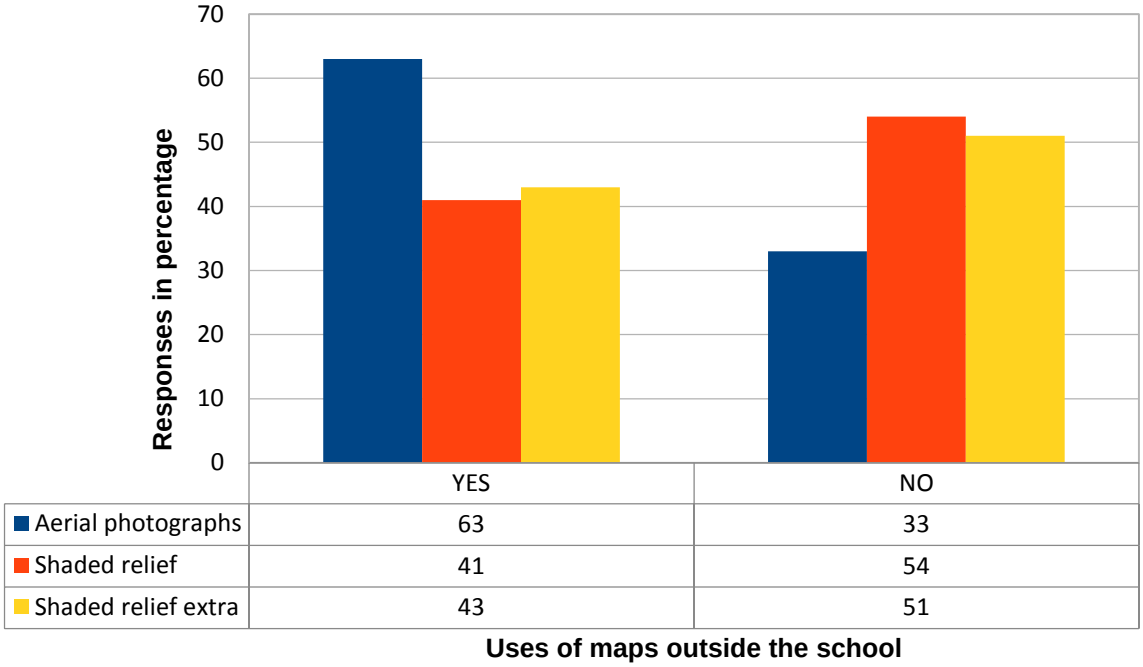
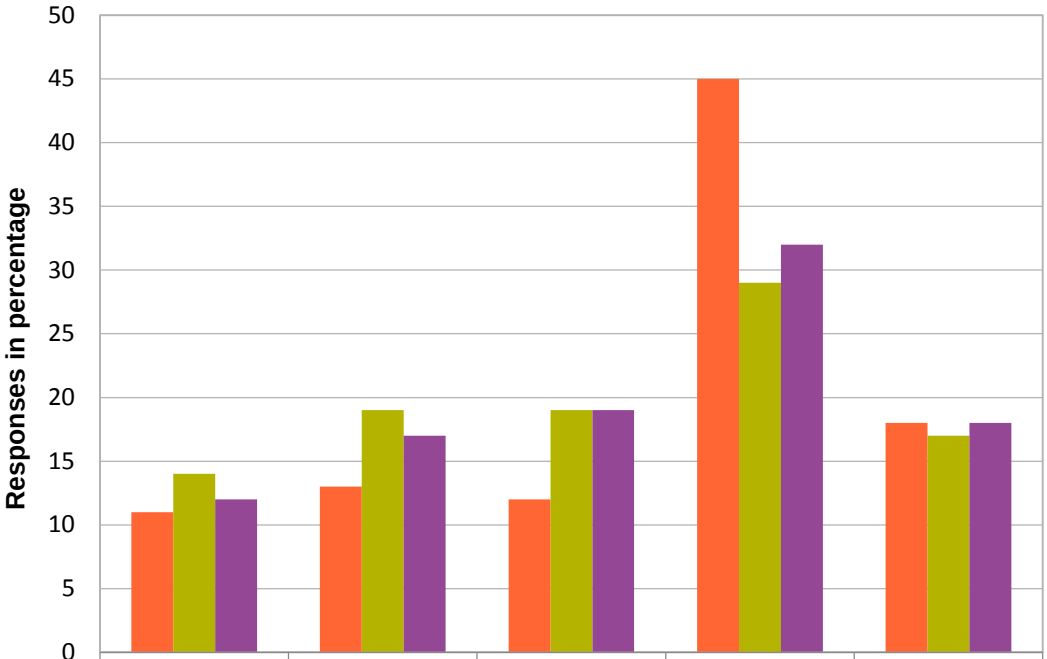


Figure 9: Responses from the participants on the use aerial photographs, shaded relief maps and shaded relief maps with additional information outside the school.

4 .6 Choice of maps

Regarding similar task (identification of spatial phenomena), participants were also asked to indicate their choices among the three types of maps (aerial photographs, shaded relief maps and shaded relief maps with additional information. (Figure 10), below shows that, for *definite not use,* aerial photographs had 11%, shaded relief maps 14% and shaded relief maps with additional information 12%. *For may be not use,* aerial photographs had 13% shaded relief maps 19% and shaded relief maps with additional information 17%. *For not use,* aerial photographs 12%, shaded relief maps 19%, shaded relief maps with additional information 19%. *For my be use,* aerial photographs 45%, shaded relief maps 29% and shaded relief with additional information 32%. *For definite use,* aerial photographs 18%, shaded relief 17% and shaded relief with additional information 18%



	Definite not use	May be not	Not sure	May be use	Definite use
Aerial photographs	11	13	12	45	18
Shaded relief	14	19	19	29	17
Shaded relief extra	12	17	19	32	18

Figure 10: Showing choice of maps by participants if exposed to similar task

Additional to map choice (Figure 10), participants were also asked to mention other types of maps which they could use. Their responses have been summarized in (Table 5)

Types of map	**No of responses**
Contour map	6
Topographic map	18
Oblique photograph	2
Terrestrial photograph	4
Statistical maps	3
Population map	1
General view photograph	1
Close up photograph	1
Map (without specification)	1
Photograph (without specification)	2

Table 8: Responses from participants for other types of maps in similar task

4 .7 Technology and exposure

4 .7. 1 Google maps

Participants were also asked about technology and see how they are exposed to science and technology. (Figure 11) below shows the response from the participants. The overall responses show that, 47% of the participants are familiar with Google maps, 50% are not familiar with Google

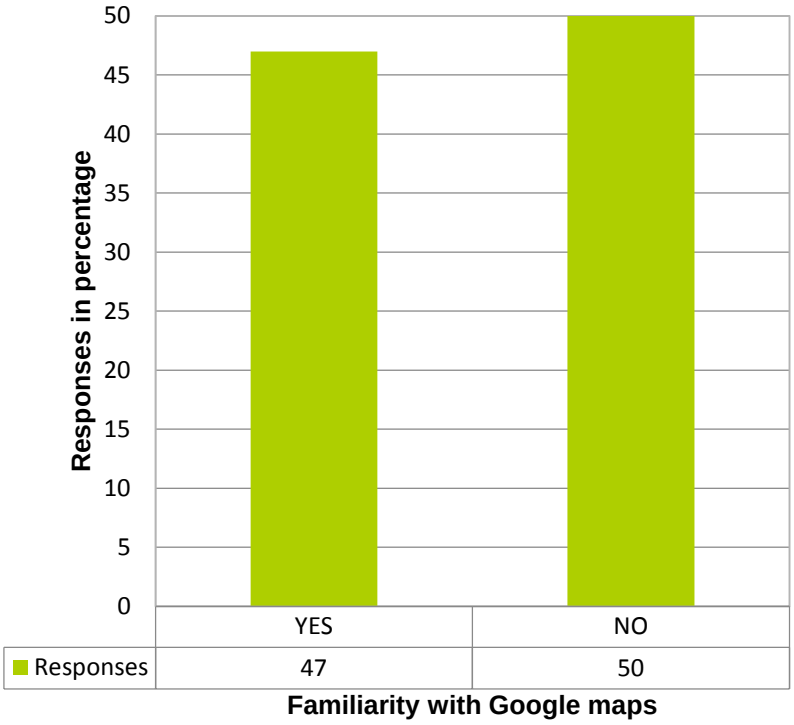


Figure 11 showing Google map familiarity among the participants

4. 7. 2 Frequency access to Google maps

We were also interested to know how frequently our participants access Google maps A breakdown of responses is given in (Figure 12) below, which indicates that, 25% of participants never access to Google map, 22% access Google map very frequently, 17% access the map frequently, 14% rarely access Google maps, 3% access occasionally.

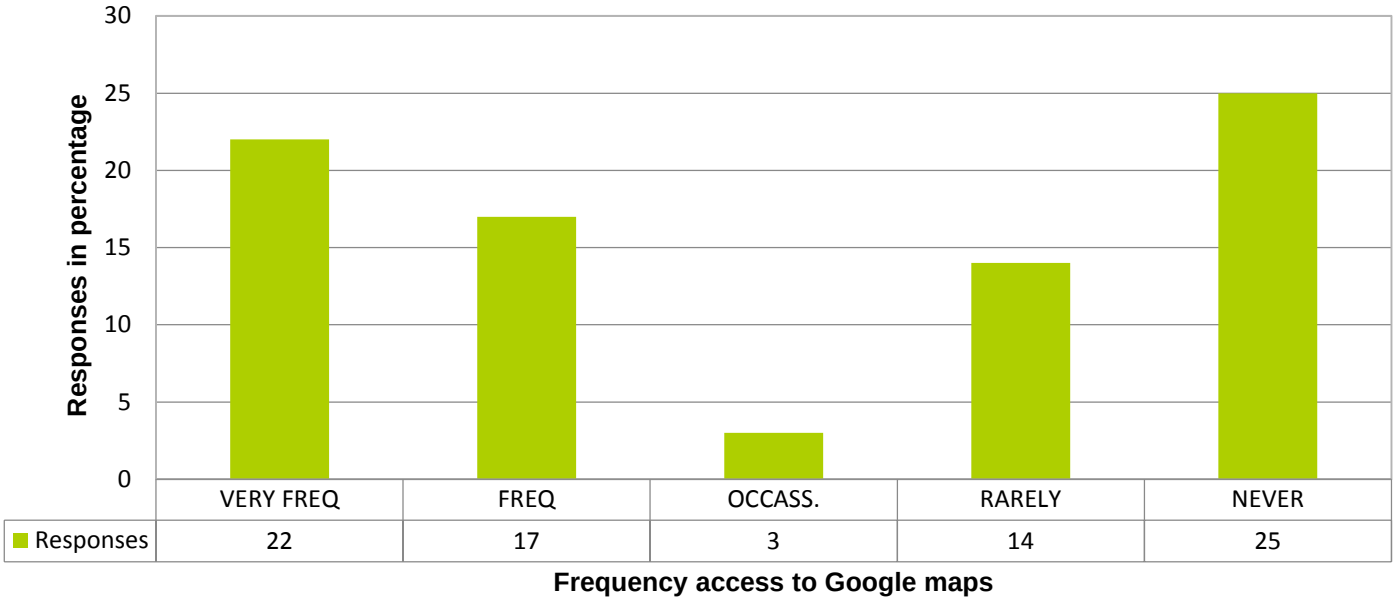


Figure 12: Frequency access to Google maps

4. 7. 3 Media preference

Participants were also asked to state their preference when they want to view aerial maps, shaded relief maps and shaded or other types of maps. Their responses are shown here below in (Table 9) indicating a majority of the participants (30%) preferred to view the maps by computer, followed by 24% of participants who preferred to view by using the mobile phone, 23% preferred to use text books, 10% computer and mobile phones, 4% computer and text books while “mobile phone and text”, “computer, mobile phone and text books”, had 3%

Media to use	**No. of responses (%)**
Computer	30
Mobile phones	24
Text books	23
Computer and mobile phones	10
Computer and text books	4
Mobile phones and text books	3
Computer, mobile phone and text books	3

Table 9: Media preference among the participants

Participants were also asked to state how frequently they use various media as far as learning is concerned. Their responses indicated that, *very frequent* use of the media had the following results; computer (48%), mobile phones (28%), internet (25%), *frequent* use with the following results; computer (27%), mobile phones (38%), and internet (34%),

occasionally use had the following results; computer (33%), mobile phones (28%), and internet (38%), *rarely* use had the following results; computer (34%), mobile phones (27%), and internet (39%), while *never* use had the following results; computer(48%), mobile phones (16%), and internet (36%).Their responses have been also provided here below graphically. (Figure 13)

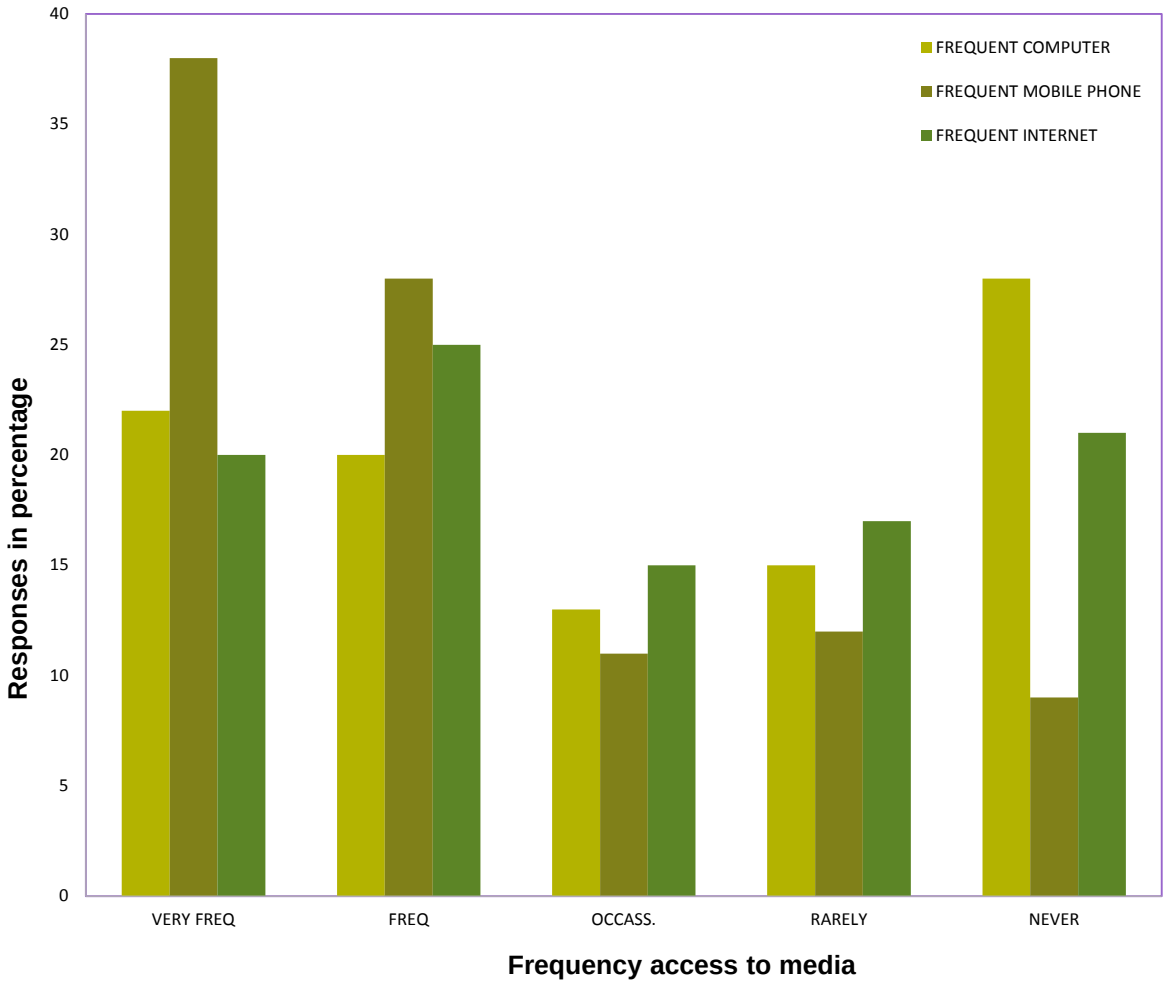


Figure 13: showing frequency use of media

5 Discussion of the results

In this chapter we will provide answers to the research questions as well as with the results obtained and available in the previous chapter. Also we will discuss what worked well in the study and areas which need some improvements

This study investigated to what extent aerial photographs, shaded relief maps and shaded relief maps with additional information facilitate the identification of spatial phenomena among the secondary school students, a case study of Tanzania. The findings from this study support the National Research Council report (2006), "*Learning to Think Spatially"* that spatial thinking can be learned, can be taught formally to all students and can be supported by appropriately designed tools, technologies, and curriculum.

5 .1 Answering research questions

5. 1. 1 Do students perform better with aerial photographs, shaded relief maps or shaded relief with additional information (accuracy) when identifying spatial phenomena?

The participants in this question, were asked to answer 24 questions (paper-based) by selecting the correct option (putting a tick) using a pencil. 100 participants answered these questions, based on aerial photographs, shaded relief maps and shaded relief maps with additional information. The findings in this question from the ANOVA (Table 4) suggest that, there was no statistical difference among the three types of maps. These findings still indicate that, students need proper guidance when observing spatial phenomena. As Bodzin (2011) points out that, much structure is needed to guide students to observe spatial patterns. The author adds that, learners may need much more exposure to analyzing different environmental contexts to help them succeed in developing spatial skills. Curriculum materials should provide necessary supports that emphasize to science teachers the importance of modeling spatial thinking processes during image interpretation and analysis tasks when using environmental contexts that students may be unfamiliar with. The performance of students as indicated in figure 5 was not good. The results can be linked to the information available in Table 6 and Table 7. The visual stimuli used in the study (aerial photographs, shaded relief maps and shaded relief maps with additional information) were not informative enough to provide necessary information for spatial feature identification. Our participants had problems to identify clearly features from these visual stimuli used in the study. Another reason which could have contributed to lower performance is lack of sufficient prior knowledge about features asked in the study. This could have been caused by either, individual cognitive capability or skills and knowledge about spatial features is not in a coherent way within the participants as some confused of one element to another element. Familiarity with geo-spatial tool could also be another reason for lower performance.

The ANOVA (Table 5) shows that, the interaction among the spatial features observed (drainage patterns, river features, physical features and features i.e. valleys) was statistically significant. Figure 6 Shows that physical features (mountains, rivers, flat land and small hills) were easily identified by the participants, compared to other features. Mountains can easily be observed from the map, even without much training. Experience can also help to identify mountains easily. Participants were able also to identify river features easily, which could have been supported by visual variable (linear) representation which help to give the direct impression of the observed phenomena. Prior knowledge for example using topographic maps could have also facilitated these features to be identified easily compared to others. Flat land and small hills were also easily identified in the study. This can be linked to the physical landscape of Dodoma where the study took place. Physical landscape in area is generally flat with small hills. Participants could have used their physical environment experience to get clues to the answers. Although river features were easily identified, we noticed concept confusion among the participants. Some participants confused the river feature (ox-bow Lake) with “U-shaped valley”. This might have been caused by insufficient knowledge and skills on various features at a particular stage of the river course development. Depth analysis on geo-spatial concepts based on development of features with their corresponding stages of the river is very important until the concept is clear to students. Drainage patterns concepts still not clear among the participants.
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5. 1. 2 Do students find it easier to identify spatial phenomena in aerial photographs, shaded relief maps or in shaded relief maps with additional information?

In this question we were interested to find out which difficulty per map type and make a comparison. The difficulty rate level was placed below the main question. The findings from this question, as indicated in Figure 7 show that, satellite images and shaded relief maps features were difficult in identification of spatial features by the participants, while shaded relief maps were the least difficult to identify the spatial features.
This implies that, the features on shaded relief maps with additional information were easy to be identified by the participants than the features on shaded relief maps and satellite images. Shaded relief maps with additional information features were the most convenient map for interpreting features than other maps. For both three types of maps, almost equal number of participants felt moderately in identification of spatial features. With respect to degree of difficulty, we asked also our participants to indicate what made the question (map type) difficult for them. The findings are summarized in (Table 6) above. Based on these findings, some participants had problems with language, *(language was difficult)* and some indicated that there were not familiar with the map, *(not familiar with the map).* The data shows that, the biggest issue to our participants was the information provided on the map. Majority of the participants indicated that either the map types *had too much information* or *too little information*, so it was difficult for them to identify the features clearly from the map type.
Additionally, participants were also asked to provide some reasons which they thought why

the map type was difficult to them. Extra reasons were obtained as indicated in Table 7, for questions (1, 4, 5, 9, 13, 14, 16, 17, 20, 22, and 24). Two major problems dominated in the responses “image not clear and difficult to identify”. These issues can be linked to the issue of information above (Table 6) as the main problems to our participants to identify the features. The difficulty level among the three types of maps used in the study varies from one participant to another depending on the cognitive level of the individual participant in solving the problem. Aerial photographs were the most difficult map type to identify spatial features. The issue of aerial photographs can be linked to the results available in Figure 11 and Figure 12. Figure 11 shows that, half of the participants are not aware of Google maps and access to Google maps as indicated in Figure 12 is limited among the participants. This could be the reason to why majority of the participants could not perform well on aerial photographs questions. The availability of Google maps enhance and support the user to view the terrain into different perspective. The issue with shaded relief maps could be due lack of enough knowledge about this type of maps. It seems students are not much exposed to use shaded relief maps in solving geo-spatial tasks.

5. 1. 3 Which media do students prefer to view aerial photographs, shaded relief maps or shaded relief maps with additional information when identifying spatial phenomena?

This was a questionnaire part in the experiment. This part included the following small parts; frequency use of the maps, use of maps outside the school, choice of maps.
Starting with the frequency use of the three types of maps (aerial photographs, shaded relief and shaded relief with additional information), the results in (Figure 7) indicate that, the participants use more aerial photographs compared to other types of maps (shaded relief maps and shaded relief maps with additional information). On the use of three types of maps outside the school, the results in Figure 9 show that, a higher percentage of participants use aerial photographs outside the school compared to shaded relief maps and shaded relief maps with additional information. Choices of maps also varied among the participants as shown in Figure 9, aerial photographs were highly favored by the participants compared to shaded relief maps and shaded relief maps with additional information. Also the participants were asked to provide other types of maps, their responses have been summarized in (Table 8) and mentioned maps like contour map, topographic map, oblique photograph, terrestrial photograph, statistical maps, population map general view photograph, close up photograph, Map (was not specified) and photograph (was not specified). The preference indicated to our participants

5. 1. 4 How do students adapt to the changing technology to learn aerial photographs shaded relief maps and shaded relief maps with additional information as far as spatial phenomena are concerned?

In this part, we started by asking if our participants are familiar with Google maps. The results in Figure 11, show that, nearly half of the participants are familiar with Google maps and half of the participants are not familiar with Google maps. This implies that, some of the participants have online access and this could also be supported by the availability of mobile

phones. The results in figure 12 also indicate that, majority of the participants have access to Google maps, and quarter of the participants shows that, never access to Google maps.
Preference on media use to view aerial photographs, shaded relief maps and shaded relief maps with additional information, as shown in Table 9, indicates that, computer was highly preferred by the participants, followed by mobile phones and text books which was the least in the preference. Also other participants indicated more than option, from the same table, the results show that, “computer and mobile phone” was highly favored, while computer and text book”, mobile phone and text books”, and “computer, mobile phone and text books” were the least in the preference. These findings imply that, the use of technologies such as computers in academic matters is very important. Our participants are motivated to test and use new technologies. Although the application of technology can be limited by financial status, the perception from the participants about technology has changed opposed to Additional to that, our participants also provided other media to use to view aerial photographs, shaded relief maps and shaded relief maps with additional information. The participants mentioned, *topographic maps, atlases, camera, television, magazine and internet.*
Also we were interested to know how frequently our participants use computer, mobile phones and internet. The results in Figure 13 indicate that, mobile phones are highly used by our participants, followed by internet, but the participants are limited to computer. The availability of mobile phones in Tanzania at low cost with the ability to access internet service provided by mobile phone companies, could be the reason why most of the participants use much mobile phones and internet.

5. 2 Limitation of the study

My study had some limitations. The study was primarily limited by finances in that, I was not able to go to Tanzania to conduct the study on site. Physical presence during study could help to observe some direct behavior and help to get a greater depth of information. Also the study could be more improved by interviewing the participants. Personal interviews could provide more information from the participants with respect to their views, attitude and knowledge. This could help to enrich qualitative data and understand participants' views and opinions. Another limitation in this study was that, in the design of the experiment we did not indicate direct involvement for each participant between experiment part I (main experiment) and part 4 of the experiment (Technology and Background information). Therefore, it was not easy to identify which participant answered experiment I with respect to part 4 of the experiment. Also we mailed experimental materials to three different schools in Tanzania, but only two collaborators mailed back the materials to us.

6 Conclusion

The study was about the identification of spatial phenomena in aerial photographs, shaded relief and shaded relief with additional information. We conducted the study among 100 Tanzanian (O-level, form three and form four) secondary school students who responded to a paper and pencil designed experiment in order to answer the research questions. Data obtained were statistically and qualitatively analyzed. Similarly, technological aspects were also included in the study in order to find out how secondary school students in Tanzania are exposed to some technological matters. Four questions were used in the study. The first question was about, accuracy in the identification of spatial phenomena in all three types of maps (aerial photographs, shaded relief maps and shaded relief maps with additional information Our results from this question, strongly suggest that, spatial feature identification was not statistically, significant in all three types of maps (aerial photographs, shaded relief and shaded relief with additional information).

The second question was about the degree of difficulty for each type of question (map type). The results in this question, indicate that, features on shaded relief maps with additional information were easier to be identified by the participants compared to other types of maps. Additionally, most of the participants had the problem with the information on the map type. They either indicated, too much information on the map, or too little information on the map. Participants also added some extra reasons. Two major problems were common, “image is not clear” and “difficult to identify”

The third question was about preference on the uses and access of media, the results in Figure 7 indicate that, the participants use more aerial photographs compared to other types of maps (shaded relief maps and shaded relief maps with additional information). On the use of three types of maps outside the school, the results in Figure 8 show that, a higher percentage of participants use aerial photographs outside the school compared to shaded relief maps and shaded relief maps with additional information. Choices of maps also varied among the participants as shown in Figure 9, aerial photographs were highly favored by the participants compared to shaded relief maps and shaded relief maps with additional information.

The fourth question was about technology and exposure. The results in Figure 10, show that, nearly half of the participants are familiar with Google maps and half of the participants are not familiar with Google maps. The results in (Figure 11) also indicate that, majority of the participants have access to Google maps, and quarter of the participants shows that, never access to Google maps. Additionally, preference on media use to view aerial photographs, shaded relief maps and shaded relief maps with additional information, as shown in Table 5, indicates that, computer was highly preferred by the participants.

The results in Figure 10 and Figure 11, indicate that, participants are motivated and happy to learn new technologies in order to enhance their geographical skills as far as spatial skills are concerned. With respect to this aspect, there is a need to diversify teaching and learning methodologies in order to enable the students to be exposed to different technologies and hence enhance their academic performance. As Milson & Earle (2008) suggest that, new Geo-spatial technologies should be integrated in geography curriculum so that to achieve goals in education. The authors add, technological gadgets, should be used purposely.

Educational stakeholders should find the best way of making geographical teaching and learning tools are productive by making sure that the learners improve their geographical skills.
For education purpose, much emphasis should be put into to computer technologies with the focus of enhancing geographical skills as far as spatial skills are concerned. As (Bodzin, 2011) documents that, GIT-supported science curriculum could help students at all ability levels in and enhance the spatial skills involved with aerial imagery interpretation.

6. 1 Future studies

Future studies should give attention to amount of information on the map type in order not to end up with confusing the participants. Also, other educational stakeholders, for example teachers who are curriculum implementers, is important to be involved in the study so that to offer more opportunity get a greater depth of information as far as spatial skills are concerned.

6. 2 Personal closing word

The study has been so helpful to me since when we were in the process of choosing images relevant to the level of the participants. The whole process has been of advantage to me as I have been able to enhance my Geo-visualization and statistical skills. Additionally, the study has been as a catalyst to me to work with research related activities so that I can enhance my research skills.

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Appendix

A-Consent form

No. of Participants

Purpose of the study

Geography is one the compulsory subjects taught in secondary schools. The main purpose of this study is to find out/see whether students are able to identify spatial phenomena when introduced/exposed to different map types. The study is a partial fulfilment for master degree.

Duration of the experiment

The experiment lasts approximately one hour.

Risks in the study

There are no physical, emotional or psychological risks/effects in this study. The research work is part of what they learn in geography subject. The students are not likely to feel un-comfortable while participating in this study.

Benefits of the study

Since the study reflects what they learn, they will have an opportunity to make a revision of what they have learned and potential for their coming final form four exam.

Confidentiality

Privacy in this study is protected, student's responses will be used only anonymously for statistical analysis as far as this research work is concerned.

Compensation

A small gift will be given to students as appreciation for their participation in the study.

Voluntary participation

Participation in this study is voluntary. If a student does not feel comfortable participating in the study, he/she is free to withdraw from the study at any time without giving reasons.

Feedback

If students are interested to get a copy of the results from this study, please tell them to leave their names and contact details to you (we provide a sheet for this), and a copy of results will be mailed to them as soon as they are ready.

Confirmation to participate

I confirm that, I have read and understand the information about this study and I am ready for my students to participate in the study.

Name of Teacher	Date	Signature
Name of Researcher	Date	Signature

B-Instructions to teachers

Instructions to experimenter (teachers)

(a) General information

Format of the experiment

The experiment is classroom based and students should be informed on how to participate in the experiment. The experiment will last less than one hour.

Room for the experiment

- The room must be big enough (at least to accommodate 50 students), well ventilated, with enough supply of light.
- Chairs and tables for the participants.

Participants

Participants for this study are students who have already covered the topics of maps and photos. If possible form three students can also be allowed to participate if they have already learned these topics.

Consent form for participants

Please sign the consent form on behalf of the students. Participation in this experiment is voluntary, therefore a student is free to withdraw from the experiment without giving reasons.

Risks in the study

There are no physical, emotional or psychological risks/effects in this study. The research work is part of what students learn in geography subject.

Incentives and compensation

The participation is voluntary and no financial or credit incentives are offered. To express our gratitude with a small gesture, students each will get a pencil (which they can use during the experiment and keep it afterwards)

Treatment of participants

In order to prevent negative attitude towards the experiment, please treat the participants with high dignity and respect.

(b) Procedure on how to organize the session in the experiment room

Having got the required sample for the experiment, please follow the procedure below:

- Arrange the students in their respective seats.

- There are three sections in the experiment sheet. Give them the document labelled **Part 1** and pencils.
- Read the instructions (document labelled *instructions to the students*) loudly to the participants.
- Allow them to start the experiment, announce the time. Allow **25 minutes for Part 1**.
- Please stay in the room during the whole time of the experiment, so that you can help the participants in case they have problems. Please *do not* give them the correct answer.
- Do not allow any communication among the participants in the experiment's room.
- Food or drinks should be handled carefully in the experiment room.
- Once the participants complete their tasks, they should leave the filled documents on the table and will be collected by you.
- When Part 1 is finished, repeat the procedure for Part 2. **For Part 2, allow 10 minutes.**
- When Part 2 is finished, give them the sheets called Part 3. **For Part 3, allow 5 minutes.**
- When Part 3 is finished, give them the sheets called Part 4. **For Part 4, allow 5 minutes.**
- At the end of the session, please announce that we would like to thank them for their participation and send our best regards from Switzerland.
- If necessary (and if possible), we can communicate through Skype, or phone during the experiment if something is not clear at all to any of you. Tumaini Kitara phone: +41 78 260 63 32, Skype tumaini.kitara, email: tumainikitara@yahoo.com.
- Once the experiment is complete, please **make a photocopy (or scan, if possible)** of every answer sheet and keep them. If you have to pay for this, please keep a receipt and send us a copy of the receipt, we will re-imburse you.
- Send back the original answer sheets, signed consent form and the feedback request list to us in a sealed envelope by **registered post**. We will cover the postal expenses, however, *please* ***avoid DHL*** as their prices are beyond out budget. Post can be addressed to:

  Dr. Arzu Coltekin
  Department of Geography
  University of Zurich
  Winterthurerstrasse 190
  8057 Zurich

- Please find a small gift for yourself as a sign of our gratitude for your help.

Thank you very much for your cooperation!

C-Instructions to the students

Instructions to the students

Dear students,

Greetings from Switzerland! Thank you for agreeing to take part in this small experiment. This is a small research project we are conducting at the University of Zurich, Department of Geography in Switzerland.

Remember that this is not an exam, however we encourage you to do your best. You will not be identified, this means please do NOT write your name on the sheets.

If you do not understand a particular word, you can ask for help, but please do not ask for the correct answer. Also, please do not talk to each other during the experiment.

The experiment has four sections. You will be given Part 1 first and work with this for 25 minutes. When you complete this, Part 2 will follow, which will last 10 minutes. Part 3 and Part 4 will each last only 5 minutes.

If you want to hear the results from us, please leave your name and contact information on the sheet “feedback request form” (on your teacher's desk).

All the best!

D-Experiment

Experiment
PART I

General instructions for this experiment:

- This study is a part of a research project. We are interested in understanding geographic learning process in relation to map types.
- Your responses will be **confidential**, and your co-operation would be **greatly appreciated.**
- Please **do not** sign in your name.
- Your participation in this study is **voluntary**, if you are not comfortable to participate, please feel free to withdraw from the experiment.
- Communication is **not** allowed among the participants during the experiment. This can lead to the exclusion from the study. In case you have any problem, please **raise** your hand and the teacher will come to help you.
- **Thank you for your cooperation and understanding.**

The experiment (Part 1)

- You are provided with (24) questions. Please, read the questions carefully, look at the figure given and then choose the correct answer from the five options for each question, by putting a tick (√) in the box provided on the right hand side. If you don't know the answer, choose “I don't know”.
- Please use the pencil which you have been given to answer these questions (you are welcome to keep the pencil after the experiment!).

What type of drainage pattern can develop in this figure?

a	Centripetal	
b	Radial	
c	Ox-bow lake	
d	Dendritic	
e	I don’t know	

How difficult did you find this question?

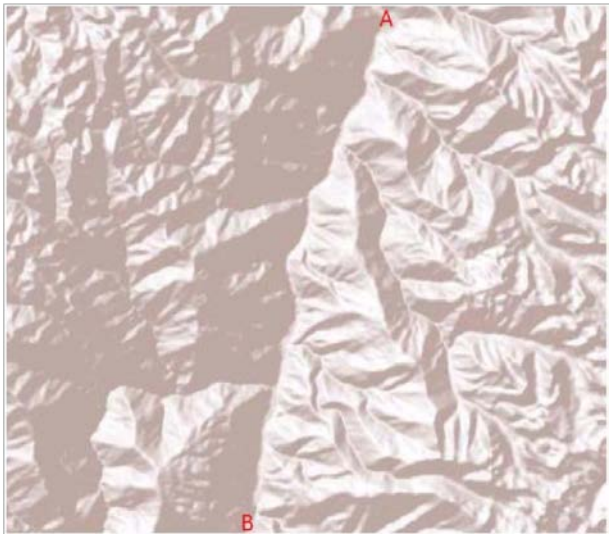
Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

Which feature can you identify in this figure, from A to B?

a	Hill	
b	Ridge	
c	Valley	
d	Delta	
e	I don't know	



How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

Which physical features can you identify in this figure?

a	Settlements and mountains	
b	Settlements and rivers	
c	Rivers and settlements	
d	Mountains and rivers	
e	I don't know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?

(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

What type of river feature is likely to develop in this figure?

a	Crater	
b	Delta	
c	Ox-bow lake	
d	U-shaped valley	
e	I don’t know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

What type of river feature can you identify in this figure?

a	Crater	
b	V-shaped valley	
c	Delta	
d	Ox- bow lake	
e	I don’t know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

Which physical features can you identify in this figure?

a	Flat land and small hills	
b	Flat land and rivers	
c	Crater lake and hills	
d	Delta and flat land	
e	I don't know	

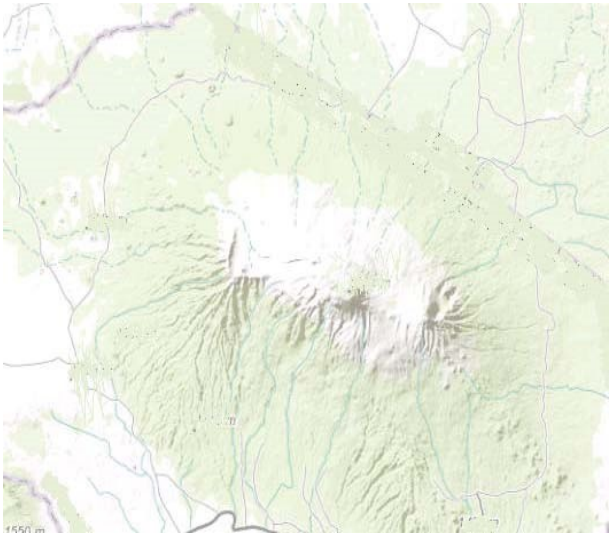
How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

Which type of drainage pattern can develop in this figure?



a	Rectangular	
b	Centripetal	
c	Dendritic	
d	Radial	
e	I don't know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

Which feature can you identify in this figure, from A to B?

a	Valley	
b	Ridge	
c	Hill	
d	Delta	
e	I don't know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

What type of drainage pattern can you identify in this figure?

a	Centripetal	
b	Dendritic	
c	Ox-bow lake	
d	Radial	
e	I don't know	

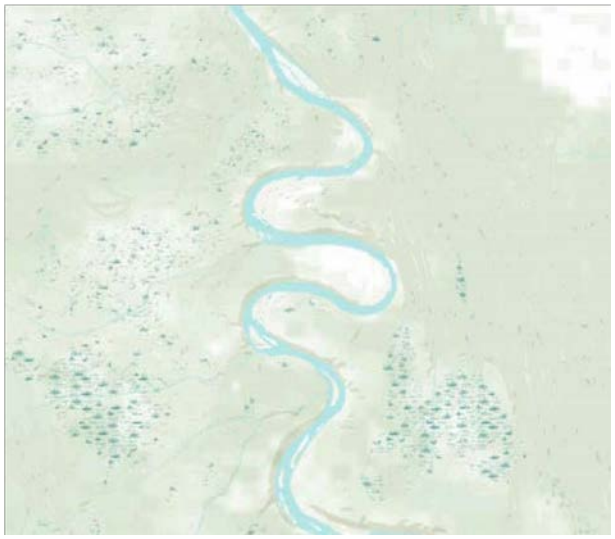
How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

What type of river feature is likely to develop in this figure?



a	U-shaped valley	
b	Delta	
c	Crater	
d	Ox-bow lake	
e	I don't know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	Too much information on the map	Too little information on the map	Not familiar with the map	If you have other reasons, please write them here:

What type of drainage pattern can develop in this figure?

a	Radial	
b	Ox-bow lake	
c	Centripetal	
d	Rectangular	
e	I don't know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	Too much information on the map	Too little information on the map	Not familiar with the map	If you have other reasons, please write them here:

Which physical features can you identify in this figure?

a	Mountains and rivers	
b	Rivers and settlements	
c	Settlements and mountains	
d	Forests and settlements	
e	I don't know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	Too much information on the map	Too little information on the map	Not familiar with the map	If you have other reasons, please write them here:

What type of river feature can you identify in this figure?

a	V-shaped valley	
b	Delta	
c	Ox-bow lake	
d	Interlocking spurs	
e	I don't know	

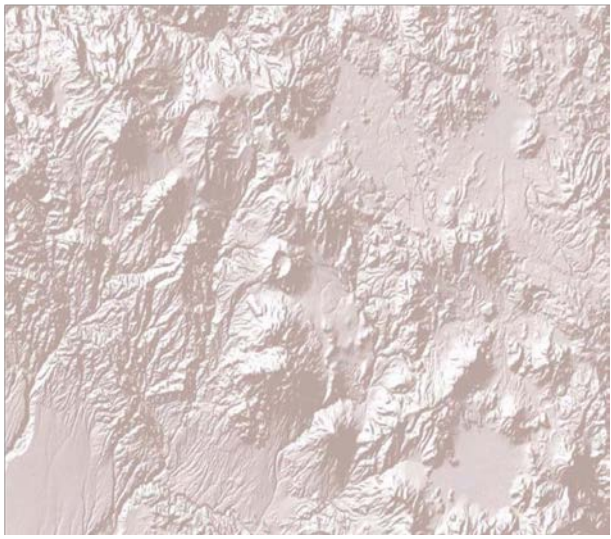
How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	Too much information on the map	Too little information on the map	Not familiar with the map	If you have other reasons, please write them here:

Which physical features can you identify in this figure?



a	Settlements and mountains	
b	Mountains and rivers	
c	Forests and settlements	
d	Rivers and settlements	
e	I don't know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	Too much information on the map	Too little information on the map	Not familiar with the map	If you have other reasons, please write them here:

Which feature can you identify in this figure from A to B?

a	Valley	
b	Ridge	
c	Hill	
d	Saddle	
e	I don't know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	Too much information on the map	Too little information on the map	Not familiar with the map	If you have other reasons, please write them here:

Which physical features can you identify in this figure?

a	Rivers and mountains	
b	Flat land and rivers	
c	Flat land and small hills	
d	Rivers and lakes	
e	I don't know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	Too much information on the map	Too little information on the map	Not familiar with the map	If you have other reasons, please write them here:

Which physical features can you identify in this figure?

a	Crater lake and hills	
b	Mountains and flat land	
c	Rivers and lakes	
d	Flat land and small hills	
e	I don't know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	Too much information on the map	Too little information on the map	Not familiar with the map	If you have other reasons, please write them here:

What type of river feature is likely to develop in this figure?

a	Delta	
b	Ox-bow lake	
c	Crater	
d	V-shaped valley	
e	I don’t know	

How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

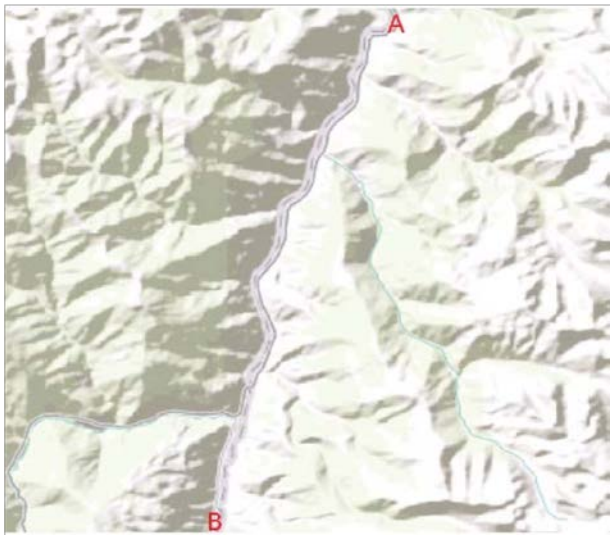
If difficult, what made it difficult for you?

(You can choose more than one option)

Language was difficult	Too much information on the map	Too little information on the map	Not familiar with the map	If you have other reasons, please write them here:

Which feature can you identify in this figure, from A to B?

a	Delta	
b	Ridge	
c	Hill	
d	Valley	
e	I don't know	



How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	Too much information on the map	Too little information on the map	Not familiar with the map	If you have other reasons, please write them here:

What type of drainage pattern can you identify in this figure?

a	Centripetal	
b	Radial	
c	Ox-bow lake	
d	Dendritic	
e	I don’t know	

How difficult did you find this question?

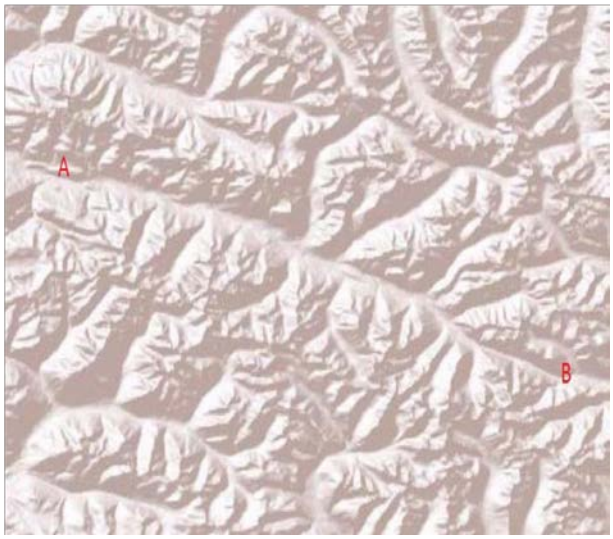
Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

Which feature can you identify in this figure, from A to B?

a	Valley	
b	Ridge	
c	Hill	
d	Saddle	
e	I don't know	



How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language wasdifficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

What type of drainage pattern can you identify in this figure?

a	Radial	
b	Centripetal	
c	Dendritic	
d	Rectangular	
e	I don't know	

How difficult did you find this question?

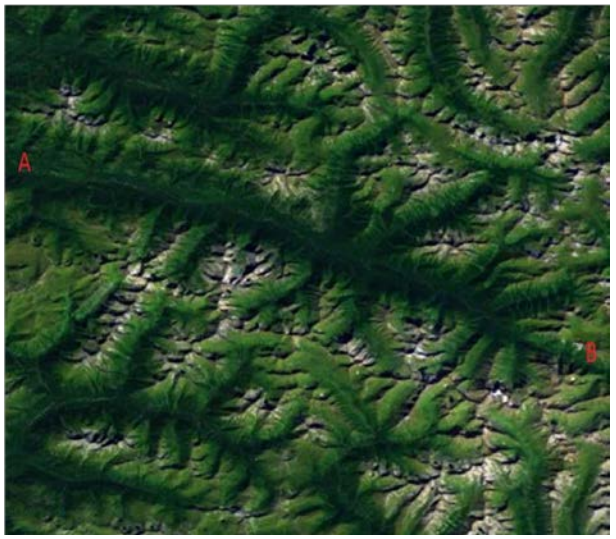
Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

Which feature can you identify in this figure from A to B ?

a	Valley	
b	Ridge	
c	Hill	
d	Saddle	
e	I don't know	



How difficult did you find this question?

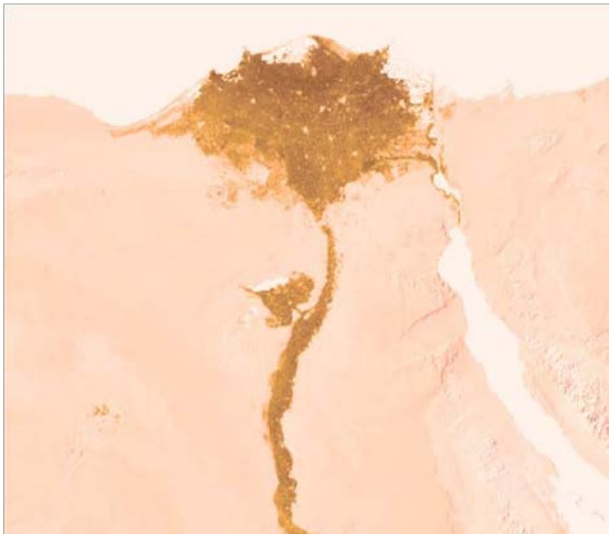
Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

What type of river feature can you identify in this figure?

a	Delta	
b	Ox-bow lake	
c	Crater	
d	V-shaped valley	
e	I don’t know	



How difficult did you find this question?

Very difficult	Difficult	Moderate	Easy	Very easy

If difficult, what made it difficult for you?
(You can choose more than one option)

Language was difficult	**Too much information on the map**	**Too little information on the map**	**Not familiar with the map**	**If you have other reasons, please write them here:**

This is the end of Part 1.

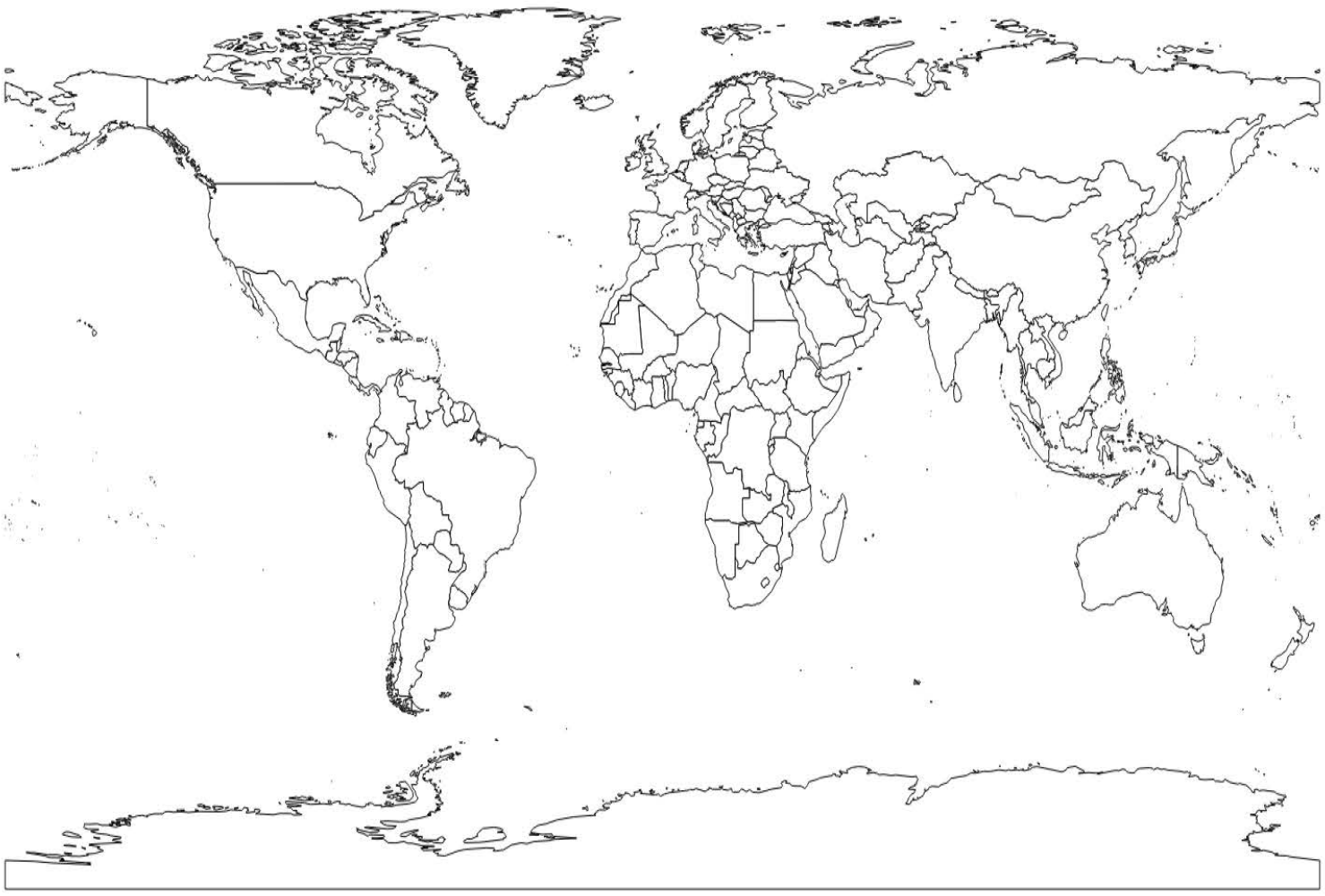
If you have finished earlier than your 30 minutes, please wait until others finish.

Thank you for your cooperation!

E-World national boundaries

Please write names of as many countries as you can.
Country names should be placed inside the national boundaries when possible.
When this is not possible, you can draw a line from the country to the label and use the empty spaces anywhere on the paper.

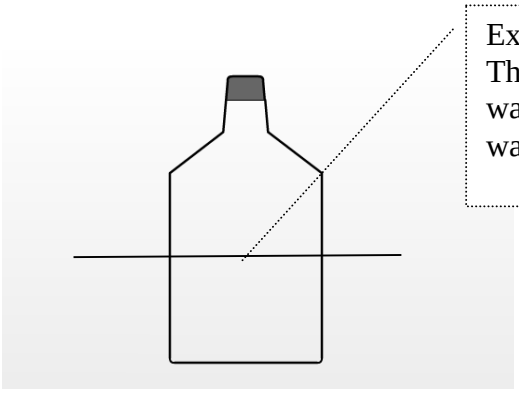
Thank you for your cooperation!



F-Water level task

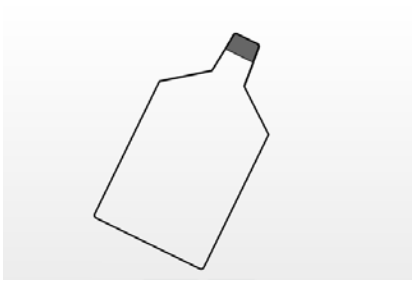
Experiment **PART 3**

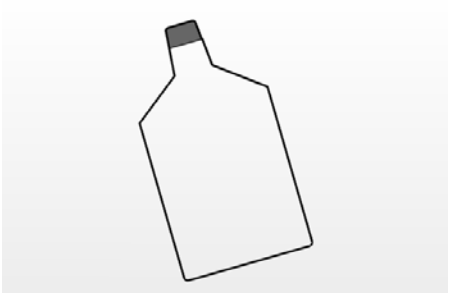
Allow approximately (5 mins), Your task: Below you will see a number of empty, tilted bottles. For each bottle, draw a line showing the water level**. If the bottles were half full.** An example (bottle not tilted)

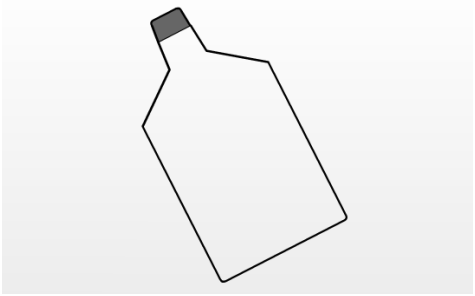


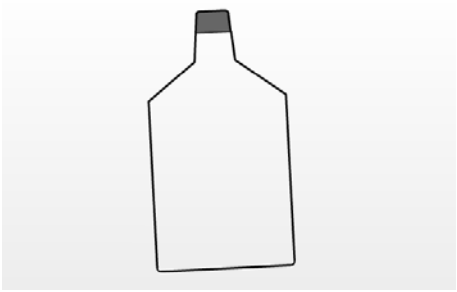
Example solution:
This line shows the water level if the bottle was half full.

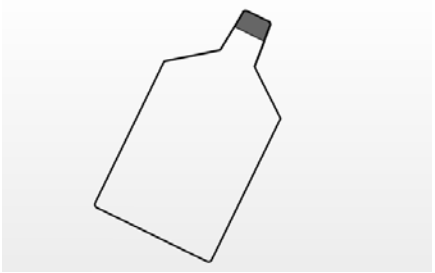
Draw the water level on each bottle below:

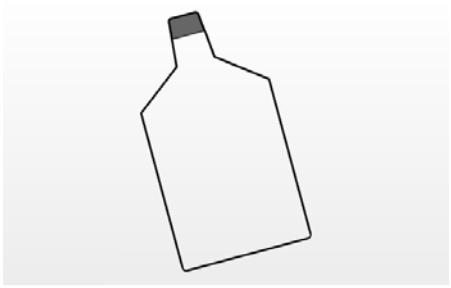


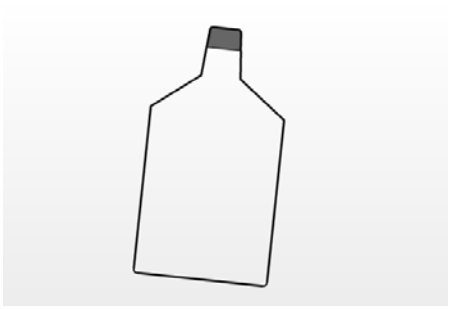


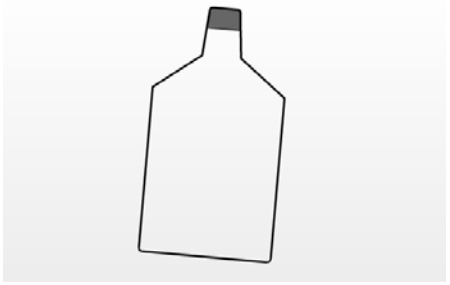












G-Technology and exposure

Part 4: Questionnaire
Please answer the following questions.

Background information

Gender:
Form:
Age:

Do you have problems with color vision?

Yes ☐ No ☐

Map Types

You have worked with three *map types* below.

An example aerial photograph (left), an example shaded relief map (middle), and an example shaded relief map with additional information (right)

Please mark your response to the following statements.

1. How often do you use aerial photographs?

Very often	Often	Sometimes	Rarely	Never

2. How often do you use shaded relief maps

Very often	Often	Sometime	Rarely	Never

3. How often do you use shaded relief maps with additional information?

Very often	Often	Sometimes	Rarely	Never

4. Do you use any of these three map types *outside* the school?

Aerial photographs: Yes ☐ No ☐

Shaded relief maps Yes ☐ No ☐

Shaded relief maps with additional information Yes ☐ No ☐

5. If you could chose, *would you use* these map types for tasks similar to those you have answered?

Aerial photographs

Definitely would not use	Maybe would not use	I am not sure	Maybe would use	Definitely would use

Shaded relief maps

Definitely would not use	Maybe would not use	I am not sure	Maybe would use	Definitely would use

Shaded relief maps with additional information

Definitely would not use	Maybe would not use	I am not sure	Maybe would use	Definitely would use

If you would *rather* use another map type, which map type would this be? For example, contour maps, topographic maps, terrestrial (not aerial, but 'normal') photographs, or others. Please write in the box below.

Technology

6. Do you know Google maps?

Yes ☐ No ☐

If yes, how often do you use Google maps?

Very frequently	Frequently	Occasionally	Rarely	Never

7. Which of the following medium do you use when you view aerial photographs, shaded relief maps or other types of maps? (You can choose more than one option)

Computer	Mobile phones	Text books

Others:

8. How frequently do you use a computer?

Very frequently (every day)	Frequently (every week)	Occasionally (once a month)	Rarely (less than once a month)	Never

9. How frequently do you use a mobile phone?

Very frequently (every day)	Frequently (every week)	Occasionally (once a month)	Rarely (less than once a month)	Never

10. How frequently do you access internet?

Very frequently (every day)	Frequently (every week)	Occasionally (once a month)	Rarely (less than once a month)	Never

This is the end of the experiment. Thank you for your cooperation!

H-Feedback request form

Feedback request list If you would like to hear the results of this experiment, please add your name to this list	
Name	**Email address or home address (e-mail preferred if possible)**

Personal declaration

I hereby declare that, the submitted thesis is the result of my own, independent work. All external sources are explicitly acknowledged in the thesis.