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Applying the Research-Based Outdoor Study on the Climosequent Topic to Improve Scientific Thinking Skills

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Geographic studies that examine the phenomenon of the geosphere provides opportunities for learning in the field. Geography has provided material objects to undergo natural geomorphic processes. Weathering is one of the geomorphic processes caused by the climate. Climate engenders weathering processes, dissolution, and the removal of material in vertical and horizontal effects on soil properties. Students are directed by research procedures based on the hypothesis that has been formulated to establish scientific thinking skills. This research method uses action research by the Kolb cycle through steps, concrete experience, reflective observation, abstract conceptualization, and active experimentation. The number of students is as many as 40. Student activity starts from the engagement proposal, hypothesis formulation, data collection, discussion, and reporting. Acquisition of scientific thinking skills are exhibited using a test. Results can be described at every step with an analysis using paired t-test between pre-test and post-test. The concrete experience involves students making the determination of point coordinates on a map where Vertisol soil types are identified in the field using GPS. Observation of soil properties as climate effects are confirmed with the hypothesis. Students reflect on the observations and find arguments based on previous knowledge. In relation to abstract conceptualization, students discuss findings supported by literature and journals. Active experimentation involves the scientific thinking skills of students in experimentation experiences regarding the new phenomenon of climate effect on the soil properties. Analysis using paired t-test between pre-test and post-test showed significance at the level of 0.00. Scientific thinking skills can be established by the research-based outdoor study. This means that scientific thinking skills can be improved through a research-based outdoor study in climosequent.

Key words: *Research-Based Outdoor Study, Scientific Thinking Skills, Climosequent*

Introduction

Ontology is a science that has an empirical study that includes the material object and formal object (Mark, Smith, & Tversky, 1999). Ontology geography studies the phenomenon of the geosphere as a material and spatial object, and the ecological and complex area as a formal object. The existence of material objects produce a formal study on the geography of a particular site as a space phenomenon. Therefore, outdoor study characterizes the geography lesson also called field-based learning (Hirsch & Lloyd, 2006), outdoor education, out-of-school learning, out-of-classroom learning, and outdoor learning (Fägerstam, 2012).

Field-based learning has been conducted by geography students periodically every year. Field-based learning focuses on observation activities for the introduction of physical landscapes without beginning with problem statements and hypotheses. Students record through sensory devices to recognize physical landscape phenomena and to find the causal factors supported by literature and journals. Because students do not have a hypothesis, the data collected through the observation sheet is global. As a result, data such as mosaics is loose and scattered. Thus, student activities through field-based learning are primarily aimed at the introduction of objects and convergent thinking skills. Based on this problem, innovation in field-based learning activities is needed by involving students in the preparation of problem statements and hypotheses. Thus, field-based learning can turn into research-based outdoor study. This makes students focus on the data collected and the goal. Convergent, divergent, inductive, deductive, and procedural thinking skills can be developed.

Outdoor study provides students with proximity to the object of study, which is directly seen, touched, and is a recognizable figure. Direct experience can improve the mastery of concepts because students can construct a meaningful learning experience. Students not only see, touch, and recognize the figures but also can identify the objects and look for reasons why the objects are in this space. Students are directed to assess the physical phenomenon and find historical processes associated with space. Thus, the students have been conducting research that came to be known as a research-based outdoor study. Rickinson gave the name of outdoor learning (Rickinson et al., 2004).

Students conduct research on the physical landscape that has been planned together between lecturers and students. Research into the basic model of learning involves students designing their own research. Research-based outdoor studies provide direct experience (Reese, 2011) and is designed (Knutson, 2003) for reflective thought and action (Miettinen, 2000), which is a different experience from reading literature or learning in the classroom (Kolb, 2005). Research-based outdoor studies are designed to be a meaningful activity that is fun and involves all the senses.

Students conduct esearch activities by determining the object point using a map and GPS. Vertisol soil is the type of material object. Vertisol soil affected by tropical climates that have different wet and dry seasons is very firm. In the dry season, the soil becomes dry and cracked, but in the rainy season the soil expands. The dry material in the fracture surface of the ground is broken, so that the top surface horizon is buried at the bottom reversal horizon. Students identify objects using eye senses, taste, and soil test kits, as well as take soil samples for analysis in a laboratory. Research activities are conducted in groups at the point of different objects but the same type of soil. Students do research in accordance with scientific procedures and provide a reason critically. Research activity is based on the hypothesis and to find the data and literature to verify it. Research activities can train students to have a scientific way of thinking (Strauss, 2015; Magno, 2010) and competence in research (Bennett, Broad, Nelms, & Terenzini, 2007).

Theoretical Review

Outdoor Study

Outdoor Study was done in the study of geography, which includes aspects of the space phenomenon called spatial science (Gabler 2007; Gabler, 2009). The phenomenon that occurs in the field cannot be presented in the classroom, so students have to experience it for themselves (Demirkaya 2010; Zink & Boyes, 2006). Outdoor Study was called by John Dewey outdoor education (Quay & Seaman, 2013, Fägerstam 2012). Phyllis Ford called it environment education (Quay & Seaman, 2013). Kolb called it experiential learning (Dunn & De Saintonge, 1997) and experience-based learning (Andresen et al., 1999; Ord, 2012). Learning outside the classroom occurs through a series of experiences and learning outcomes because of the transaction synergies between students and the environment (Kolb 2005; Kolb & Kolb, 2008). Students can do research activities for the mastery of the concept and its implementation in a live case with a *high level of active involvement* (Gentry, 1990). Experiential learning is a key element of analysing the learning experience through reflection, evaluation, and reconstruction (Andresen, et al., 1999) . Kolb called it active experimentation.

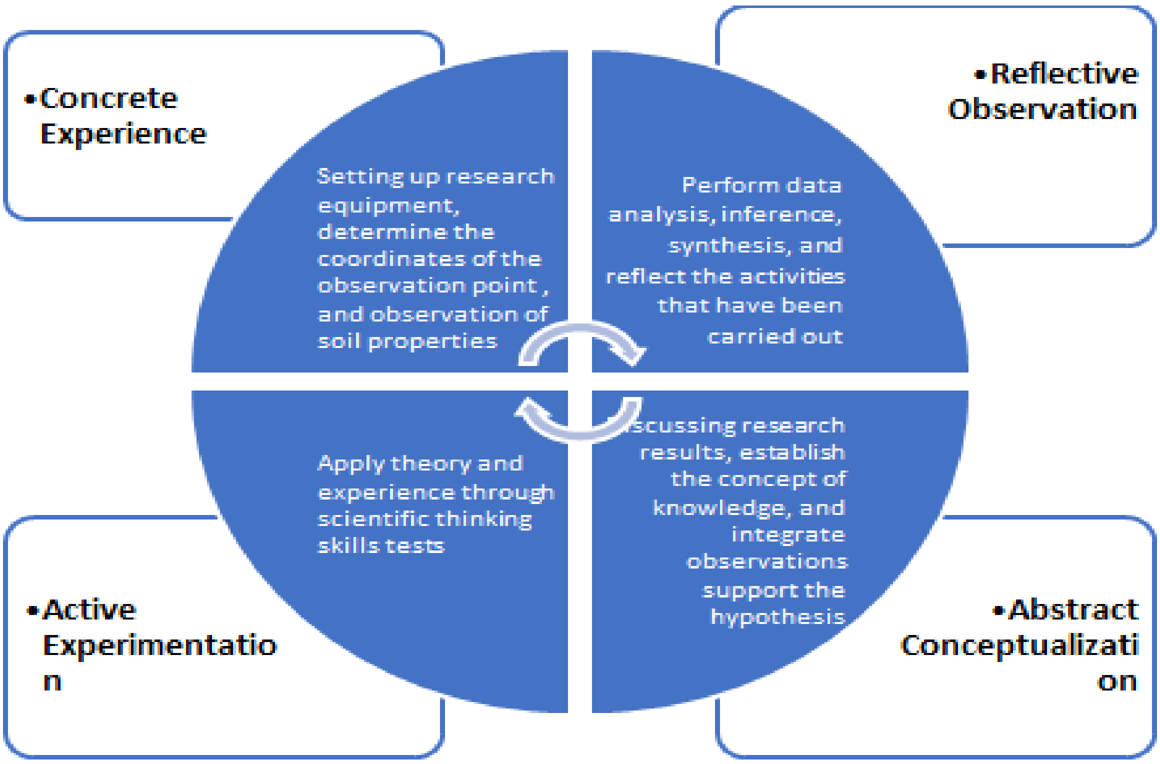
Dewey believed that learning can be a vehicle for filling experience and building creations to improve quality (Taniguchi, 2004). Experience and quality can be obtained by students through research activities as a new experience (Aytekin, 2011). Students construct their own knowledge (Olusegun, 2015) through scientific thinking skills. Scientific thinking or higher reasoning abilities (Abdullah, 2008) is a mode of thinking (Paul & Elder, 2012) or mental processes (Dunbar, 2004) which is used to give a logical answer involving cognitive operations (Das, 2014) based on evidence (Magno, 2010), or the coordination of theory and evidence (Kuhn & Pearsall, 2000). Scientific thinking has elements based on the construction of a creative mind. Elements of scientific thinking include: critical thinking, predicting, clarifying, interpreting, looking for arguments, as well as divergent, convergent, reflective, inductive, deductive, and procedural scientific thinking (Das, 2014).

Similar research based on outdoor environmental study showed an increase in scientific thinking skills (Prakasiwi & Ismanto, 2018). Nugroho & Hanik (2016) show an increase in cognitive learning outcomes. The findings of Kurniangsih, Darsiharjo, and Maryani (2015) show an increased understanding of the concept. The results of Sejati, Sumarmi, & Ruja (2016) show an increase in the ability to write scientific papers. The results of Sulasih, Syamwil, & Wilonoyudho (2017) on outdoor study show it to be capable of improving learning outcomes. The research of Orion & Kali (2005) show that earth-science learning programs have an influence on scientific thinking skills.

Methods

The study was designed using action research based on the cycle of Kolb. Students conduct research activity based on the Kolb cycle (see Figure 1): concrete experience, reflective observation, abstract conceptualization, and active experimentation (Hills & Swithenby 2010; Manolas & Kehagias 2005; Sharlanova 2004; Haley, 1999; Hills & Swithenby 2010; Baker, Robinson, & Kolb, 2012; Dhanapal, Cheng, & Lim, 2013). This was developed by Kurt Lewin (Arsoy & Özad, 2004).

Figure 1. Kolb Cycle in Research-Based Outdoor Study



Research subjects include as many as 40 students in one class. Scientific thinking skills are measured through tests, namely pre-test and post-test. The influence test is done by means of the difference test between the pre-test and post-test values using paired t-test.

Results and Discussion

Description of the activity of students in applied learning model research-based outdoor study:

Pre-Concrete Experience

- Understanding the concept of the properties of the soil, the introduction of tools, and materials in research. Tools include: soil test kit, copper ring, meter, H2O2, HCl, distilled water, pH indicators, drill soil, soil maps, and GPS.
- Understanding of research procedures, starting from the phenomena occurring in Vertisol soil types, which are plotted on a map with the soil-base as the coordinate.
- Developing hypotheses, observations and field measurements of soil properties, taking samples of undisturbed soil using a ring cooper, examining the nature of the soil in the laboratory, discussing, concluding and reporting the results. This research procedure is performed by students in groups according to the hypothesis that they set.
- Confirming the hypothesis in each group so that no hypothesis is the same based on the understanding of the concepts that have been mastered. The hypothesis is based on the phenomenon that occurs on a Vertisol soil type, which is very hard when dry and very sticky when wet. It was also noted to be dry and cracked when wet, and is known to puddle for a long time after ain. Hypothetical student example:

The Vertisol soil type is influenced by rainfall that occurred in the area of karst. Vertisol soil type occurs in the basin. Vertisol soil type is dominated by clay fraction. Vertisol soil type does not have a clear horizon. Vertisol contains little organic material. The development of the horizon is influenced by climate. Vertisol experiences wrinkle development which is controlled by a strict tropical climate.

- Determination of the coordinates of the point on the map ground research.

Concrete Experience

- A predetermined point coordinates students to research and pinpoint locations based on GPS. A research point overlay an area of Vertisol soil types.
- Descriptions point to the area of research. Description of the site Vertisol soil types, include vegetation on the surface and the growth of vegetation, topography, elevation, and soil cultivation by farmers.

- Identify types of Vertisol soil by the surface through features such as cracks, colour, and consistency.
- Drilling soil and preparing the results of drilling starting from the surface to a depth of 150 cm, which describes the soil profile.
- Analyse the nature of the soil due to climatic influences, such as the width and depth of the crack, wrinkled leaves and flowers, clay texture due to dissolution in the rain, and the reversal horizon. The properties affected by climate may be determined by the feeling method using soil texture, soil colour using Munsell Soil Colour Chart, the pH using a pH indicator, organic matter content using H2O2, lime content using HCl, and consistency using a hammer.
- Analyse soil samples in the laboratory to determine the specific gravity, weight volume, porosity, texture, structure, permeability, and Cole index.

Reflection Observation

- Based on test data in the field and in the laboratory in accordance with the hypothesis of each group, conduct a group discussion to verify the hypothesis. Students can develop the discussion through various resources.
- Synthesis, inference, and conclusion regarding the research results.
- Reflection based on the experience of previous research done by the students. Reflection is intended to correct me and remedial efforts in the next research. The results reflect that the student experience can increase retention in long-term memory.

Abstract Conceptualization

Students discuss the results of research by way of discussions and studies that support the logical theory. The discussion is intended to bring together the results of research based on the hypothesis with the relevant theory. The following is an example of the discussion of the results:

- Vertisol soil types are dominated by clay fractions as a result of leaching by rain. Observations show very sticky properties under humid conditions, very hard in dry conditions, the surface of the ground-breaking cracks in the dry condition and occurs when rain puddles. Clamminess occurs in the fine fraction and properties of adhesion do not occur in the coarse fraction. Therefore, it is a very fine clay. A very sticky nature indicates a very high clay. Very high clay content affects the consistency, which is very hard, dry, cracked in pieces. Its inundation permeable is very slow. The results of field observations indicate the dominance of clay.

The results of this observation are supported by the results of Prasad (2017) and Agusman, A. Maas, Kertonegoro, & Siradz (2006), which show the texture of heavy clay with montmorillonite clay content.

Active Experimentation

Students work on the problems of scientific thinking skill tests as research experience. The problem is aimed at the achievement of scientific thinking skills. Students are asked to observe, describe, interpret, look for arguments, and practise divergent thinking, convergent thinking, reflection, as well inductive, deductive, and procedural thinking. The test comprises questions like the following:

- Why is Andisol soil found in areas of volcanic mountains, but is not found in the mountain folds and in the limestone mountains? How does climate influence the pedogenesis of Andisol soils?
- Why is Gleization found in the rice fields, plains, and in the yard, but is not found arid regions?
- Why cannot Entisol thrive in the tropics?
- Why is Oxisol and Ultisol found in humid regions?
- Why was horizon Natric found in arid compared to the humid area?

Answer key:

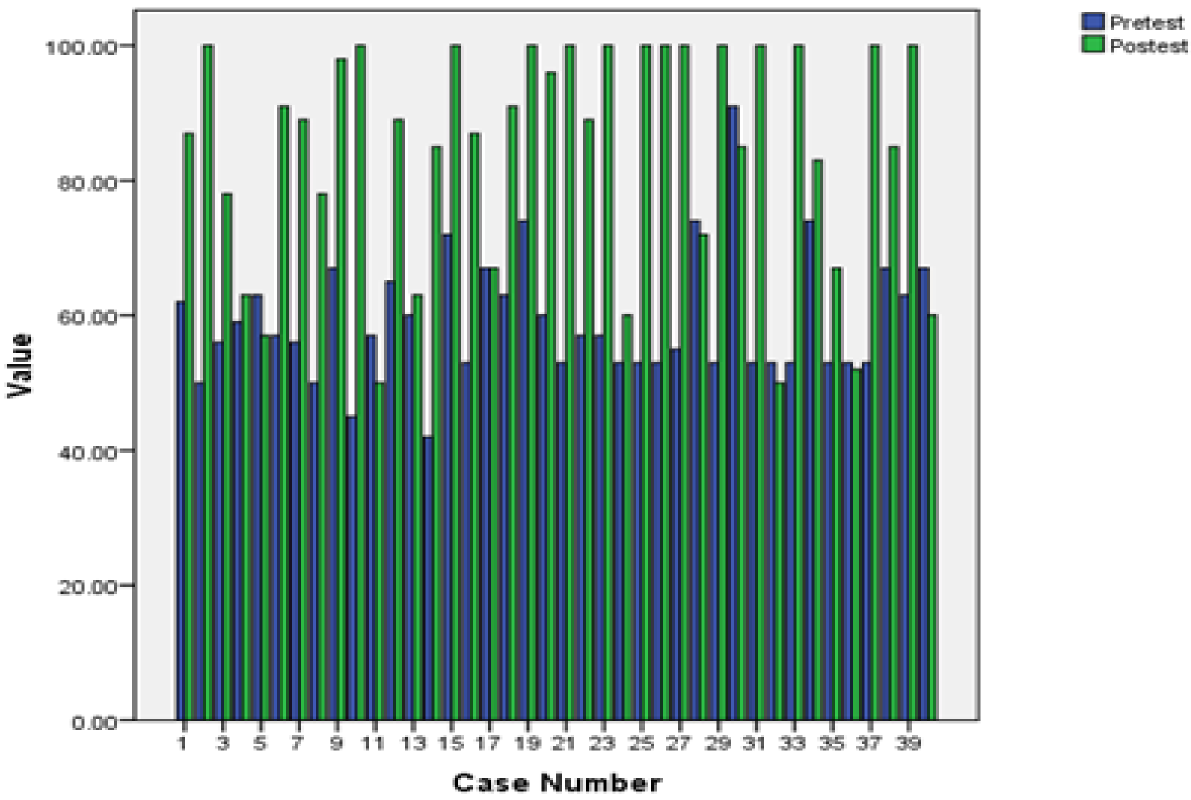
- Andisol is a land formed from volcanic ash parent material (Juarti, 2016) due to a volcanic eruption so it exists in volcanic regions. Mountain folds do not contain volcanic ash as eruption did not occur, nor in the mountains of limestone, because the material does not contain lime Andisol. Rain triggers the process of disintegration, dissolving, transporting, and settling. A firm climate in tropical regions such as Indonesia causes the soil to expand in the rainy season, and the soil to shrink in the dry season, so that the soil becomes cracked. Surface material enters into the gap of cracked soil resulting in a reversal of the horizon.
- Gleization is a process that occurs in the soil and is influenced by the presence of stagnant water such as in rice fields (Rahayu Utami, & Rayes, 2014). Lowland spaces were lower than in the surrounding areas, resulting in the flow of underground water, which leads to the plain and then a puddle and gleization. Courtyards in various rural areas are used for dumping groundwater from the shower or washing dishes. Water disposal systems are directly in contact with the ground. Puddles produce a grey colour as an indication of gleization (Paturuhu, 2010). The influence of climate with rainfall variations cause fluctuations in puddles, like in the swamp.
- Soil Entisol cannot develop because sedimentation is a new material from rain erosion conducting material transport. The addition of the new material does not give the soil a chance to grow. However, entisols could be given the opportunity to grow through the soil

by water conservation upstream, so there is no sedimentation. Conditions can develop if the river was cleaned and deepened so as to avoid overflow of river water and the formation of a new river embankment. From the river embankment, soil sedimentation entisols manifold can be developed with tillage for cultivation.

- Soil Oxisol and ultisol is a type of soil that has been developed further as a result of the effect of high rainfall. Rainfall is put through the washing process or eluviation which resulted in sedimentation of the subsoil which formed the horizon B. Eluviation's ongoing process causes the soil to be old and less productive. Soil Oxisol and ultisol does not occur in arid regions due to very low rainfall but occurs in humid regions. Ultisol and Oxisol soil productivity decreased the impact on food self-sufficiency. Therefore, it needs to be maintained through the provision of mulch on the soil surface to reduce the leaching process.
- Horizon natric occurs because of the capillarity due to high temperatures at ground level. Capillarity occurs in the capillary tube which can draw groundwater to the surface. This is because the groundwater contains salt that precipitates the salt on the soil surface. This capillarity occurs in arid regions because of high surface temperatures, whereas in humid areas it did not occur in the capillarity. Water that comes from rain does not contain salt (sodium). High sodium levels can reduce the productivity of the soil; therefore it needs to be maintained through mulching, adding organic matter, and soil tillage to break the capillary path.

The test results demonstrate the scientific thinking skills given in Figure 2. Post-test (84.3) increased from pre-test (59.15) and the mean difference using the paired t-test was significant at the 0.00 level.

Figure 2. Value of Scientific Thinking Skill



The research-based Outdoor Study model has been able to give a logic answer to scientific thinking skills. Research-based Outdoor Study prioritises experiential learning and learning by doing. Experiential learning models show the effect on understanding concepts (Anggara 2012; Fitriani, Kamaluddin & Jarnawi, 2016) and critical thinking skills (Astuti, 2016; Putu et al., 2014; Sholihah, Utaya, and Susilo, 2016). Likewise the model of learning by doing results in increased motivation and retention (Rizk, 2011).

Students who do the research directly have greater cooperation, self-reliance, self-confidence, and responsibility, which is a manifestation of scientific thinking. Through research, students learn in-depth, encouraging reflection to develop new skills, new behaviour, or new thinking (Lewis & Williams, 1994). Through research, students undertake the construction of knowledge (Bhattacharjee, 2015) and store this in long-term memory (Rickinson et al., 2004). Experience is transformative as they create (Rizk, 2011; Sirutis & Massi, 2014) and perform discovery (Ausubel, 1962; Uside, Barchok, and Abura, 2013; Yang, Liao, Ching, & Chang, 2010).

Direct student involvement makes students enthusiastic and disciplined in accordance with scientific principles, such as objectivity. Enthusiasm and curiosity in students can be realized at the time of the preparation and execution of research. At the time of the identification of the properties of soils and decision-making, students look objectively and describe the phenomenon that occurs at that time. Students are more confident in what they found themselves thus the scientific attitude has been awakened. Rickinson grouped the scientific attitude into beliefs and self-perceptions and interpersonal and social skills (Rickinson et al., 2004).

Scientific attitude directed and strengthened research activities and encouraged students to be more observant of the data of observation and analysis. Very important research data with the accuracy of data may even become basic research or evidence-based (Toom, Krokfors, Kynäslahti, Stenberg, and Maaranen 2008). Research data becomes the basis for hypothesis testing. Discussion of the results of research into the procedural stage requires a lot of time and serious thought. The student browsing information through website links, journals, and related literature supports the research. The students do the synthesis and analysis to obtain assurance about the discussion. The logic of scientific thinking inductively or deductively (Sumarto 2006; Dunbar, 2004; Das, 2014) can be awakened by means of scientific work, as well as students being awakened to scientific thinking skills.
Research activities have built procedural patterns through experience or learning by doing (Rizk, 2011; Giesen, 2011), as well as the process of introspection (Reese, 2011). Research activities fostered knowledge (Piaget) (Bhattacharjee, 2015; Siddiqui, 2017), social construction (Vygotsky) (Siddiqui, 2017) and social interaction in learning (Matthews, 2003). The students configuration of knowledge in the process of hypothesis testing can make students think scientifically (Sumarto, 2006), and reason scientifically (Yuksel & Ates, 2017; Dunbar, 2004; Morris, Croker, Masnick, & Zimmerman, 2012). Knowledge has been built by students through experience and every experience affects the next experience to build curiosity and motivation (Dewey, 1997; Roots, 2013; C.Williams & C.Williams 2011; Olusegun, 2015; Neto, 2015; Bower, 2013) and to direct more productive and innovative research (Smith & Tol, 1998).

Conclusions and Implications

The research-based outdoor study model can be applied to learning geography by directly involving students in research activities so as to improve scientific thinking skills. The research-based outdoor study could be applied to subjects that have practical and field components such as meteorology, climatology, geology, geomorphology, hydrology, biogeography, and natural resources. Students may be invited to follow the research conducted by lecturers, so that students can experience the process of accelerated graduation.

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