International Journal of Evaluation and Research in Education (IJERE)
Vol. 13, No. 1, February 2024, pp. 466~474
ISSN: 2252-8822, DOI: 10.11591/ijere.v13i1.26597

Geographic-inquiry on virtual environment mobile application to support fieldwork based on blended learning

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Article Info

Article history:

Received Jan 14, 2023
Revised Nov 23, 2023
Accepted Dec 4, 2023

Keywords:

Blended learning
Fieldwork
Geographic inquiry
Geographical thinking
Virtual environment

ABSTRACT

Implementing geography learning using the blended learning model is challenging for most geography teachers because this subject is 'hands-on' and needs to be learned directly in a real environment using fieldwork. This study aimed to test the pedagogical effectiveness of the geographic-inquiry on virtual environment (GIVE) application in supporting fieldwork based on blended learning to improve students' geographical thinking. This study used a quasi-experimental method involving 216 high school students from three schools. The paired sample t-test (Sig. 2-tailed 0.000) shows that GIVE has a pedagogical influence on students' geographical thinking. GIVE also offers a big effect size (Cohen's d=1.37). The technology and the right smartphone application can help develop a virtual environment close to a real one, so fieldwork and hands-on learning activities can be carried out in blended learning; this helps to increase the quality of geography learning.

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1. INTRODUCTION

The COVID-19 pandemic has brought significant changes to our education. Schools are now ready for the new normal after the pandemic. This is marked by the massive transition from face-to-face to online learning or blended learning [1], [2]. The shift must align with the objectives or characteristics of the subjects; some subjects must be taught and learned "hands-on" (need direct involvement), and the subjects now often present virtual environments in the learning process [3]–[8].

Geography is one of the subjects with that "hands-on" characteristic. Geography is also closely related to social and natural science; thus, teaching geography online or through blended learning has been challenging. Geography is designed to equip students with geographic thinking [9], [10]. Geographic thinking enables students to think like geographical scientists rather than merely memorize the subject matter [11]. Students must be involved in geographical activities rather than just learning materials [12]. Students use geographic thinking when engaged in the inquiry process and when investigating or applying specific skills related to different process components to meet given expectations [13].

Geographic thinking covers four factors: spatial significance, patterns and trends, interrelationships, and geographic perspective. Spatial significance requires students to determine the importance of an area or region. Students are expected to investigate the relationship between a geographical location and the physical characteristics of a site and analyze the unique relationship between the two. Then, students will understand that the same area can have different meanings for human beings, flora, and fauna. The pattern and trends insist that students recognize similar and repetitive characteristics present in the environment or human beings (patterns) and characteristics or traits showing consistent trends over time within certain trend arrangements [14]. These characteristics are related to spatial, social, economic, and environmental structures. Students analyze the relationship between characteristics to determine patterns and analyze the relationship over time to determine trends. This linkage requires students to investigate the relationship between the environment and humans [15]. Efforts to improve students' geographic thinking in learning must consider that students need time to read, sort, connect, and process information by learning thinking through geography (TTG) [16].

Learning geography must be "hands-on" and involve activities in nature; this can be done through fieldwork-based learning. Fieldwork is a signature in geography learning [17]. There have been efforts to conduct fieldwork using mobile technology [18], including creating a virtual environment through [19] and virtual laboratory development [20]. There has been an experiment for outdoor geography learning using mobile applications [21]. Post-pandemic learning of geography uses blended learning [22], [23] because fieldwork is essential for students and affects their learning [24]. Technology can ideally be used in maximizing inquiry learning in geography. Studies confirm that geography learning using technology can increase students' information and communication technology (ICT) skills and knowledge of geography [25]. Developing inquiry learning in geography must be done continuously [25]. Cellular technology is suitable for fieldwork-based inquiry geography learning [26]. Cellular technology is preferred for its exceptional mobility and ability to host various platforms of applications to support outdoor inquiry learning [27]. Points out that technical support for the investigation process in technology-based fieldwork is most important in three contexts: site identification, data collection, and monitoring.

Previous studies have not been able to create fieldwork-based blended learning for geography learning. This can be solved by developing applications that apply geography learning through an immersive virtual environment and providing students with hands-on learning experiences in nature. If it is not created immediately, it may eliminate geographic thinking as a goal of studying geography.

The modified learning experiment from Morris [28] seems suitable as a theoretical basis for developing real-world fieldwork learning models combined with virtual environments and their supporting mobile applications. Morris argues that in experimental theory, knowledge is expressed through experience transformation [28]. The experimental theory divides learning based on four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Various interpretations of concrete experience are often found when applying this theory in learning [28]. Morris provided a modification in applying experimental learning theory as presented in Figure 1.

This model is strengthened by the development of an application that is more geographic [19]. The model developed supports geography learning in blended learning [2], [29] by including direct fieldwork activities in nature [30]. We believed that the learning we develop is able to combine various kinds of geographic inquiry experiences that have never existed in previous learning models. The application developed is in the form of geographic-inquiry on virtual environment (GIVE), an application to support fieldwork-based blended learning models. The main goal of GIVE is to improve students' geographic thinking while studying geography.

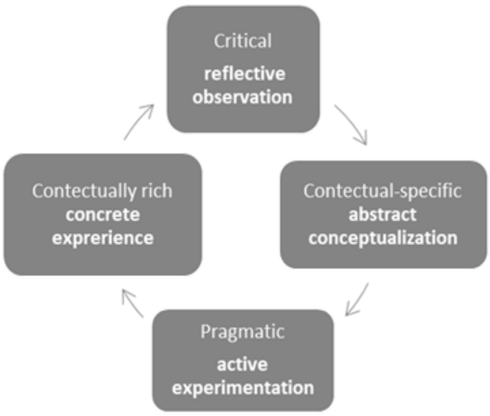


Figure 1. A modification of experimental learning by Morris

2. RESEACRH METHOD

A quasi-experimental study was conducted to assess the pedagogical effectiveness of the GIVE mobile application in supporting fieldwork-based blended learning to enhance students' geographic thinking.

The experimental group used the GIVE application in fieldwork-based blended learning to discuss the topic of "analyzing the dynamics of the lithosphere and its impact on life," while the control group also implemented fieldwork-based blended learning without using the GIVE application. Before learning, the experimental and control groups did a pre-test at the beginning and a post-test at the end of the lesson. Then, the results of the pre-test and post-test were analyzed.

Our study involved three senior high schools in South Kalimantan, Indonesia: one public school, one Islamic school, and one private school. The distance from the schools to the fieldwork site is around 0-7 kilometers; the distance was an important factor in selecting schools. In addition, schools were also chosen based on the teachers' academic background, requiring them to hold at least an undergraduate degree in Geography Education and a teaching experience of at least five years. The three schools used the same Geography textbook verified by the Ministry of Research, Technology, Culture, and Education of the Republic of Indonesia. We focused on Grade 10 in each school. We had two classes as research subjects in each school: the control and the experimental. Each class consisted of 36 students in Table 1. The total number of participants from the three schools was 216 students aged 14 to 17.

Table 1. Research participants

School	Research groups	Total students	
		Control group	Experimental group
Public Senior High School	2	36	36
Islamic Senior High School	2	36	36
Private Senior High School	2	36	36
Total participants		108	108

We developed the topic "The dynamics of the lithosphere and its impact on life" four months before the study with GIVE using Thunkable® to change it into an experiment of a six-day learning process (once a week) on a fieldwork-based blended learning framework. The control groups learned using the textbooks and finished a six-day fieldwork-based blended learning without using GIVE. We introduced the geography teachers to the GIVE pedagogical design four weeks before the experiment to minimize research bias. We asked teachers to conduct learning on "the dynamics of the lithosphere and its impact on life" after they finished the training and were confident to use GIVE. The teachers then instructed students in the experimental groups to install GIVE on their smartphones before providing a tutorial.

During the first meeting, students from the experimental and control groups completed a pretest about geographic thinking. The class was divided into nine small groups (one group consisted of four students). Then, the experimental group was instructed to follow the GIVE guidelines for the first learning activity. In this meeting, students were asked to learn the concept of the lithosphere and were shown the fieldwork location through a digital map supported by Google Maps embedded in GIVE. This location would later become a fieldwork site. Meanwhile, the control groups read lithosphere topics from textbooks.

The experimental groups were instructed to follow the GIVE instructions in the second learning activity during the second meeting. The second activity in the experimental groups required students to identify various natural landscapes worldwide, after which they were assigned to conceptualize fieldwork sites visited virtually. The control groups were brought to the fieldwork site to make initial observations.

The experimental and control groups were asked to determine or plan geographic inquiry activities at the third meeting. This activity included i) asking geographical questions; ii) obtaining geographical information; iii) arranging geographic information arrangement; iv) analyzing geographical information; and v) drawing geographical conclusions and explaining them. Control and experimental groups were involved in online synchronous learning at this meeting. Students were instructed to ask geographic questions. Students in the experimental groups completed geographic inquiry using GIVE, while students in the control groups used paper. Google Meet was used to facilitate this third meeting.

At the fourth meeting, both the control class and the experimental groups visited the fieldwork site with the teachers. The second stage of the geographic investigation process, "obtaining geographic information", was completed. Students of the control groups collected the data in the field by using GPS to determine coordinates, collected rock samples with a geological hammer, collected hand specimens in plastic, measured strike and dip with a geological compass, analyzed the mineral content of rocks with 0.1 N HCl liquid, and participated in additional activities. The activities differentiating the two groups were that students in the control groups completed everything manually, while students in the experimental class were supported by the GIVE support program in doing tasks, such as determining coordinates with the Coordinate Map®, measuring strikes and dip with Geology Compass®, identifying rocks with Rock Identifier®, and making field notes with FieldMove®.

At the fifth meeting, the experimental and control groups carried out the third and fourth geographic inquiry activities, namely organizing and analyzing data. Learning activities were carried out in the classroom or the geography laboratory. Students in the experimental groups analyzed rock samples using the GIVE program, while students in the control groups classified rocks manually. Activities involving geographic inquiry help students learn how to organize and analyze data collected in the field.

Presentations were done at the sixth meeting. Students in groups were given a turn to present in front of their classmates. A question and answer (Q&A) session happened during the presentation. The geographical investigation activity was "reaching conclusions and geographic explanations". During this meeting, students were taught how to draw conclusions, solve problems, think critically, argue, and explain the results from previous exercises. After the presentation and Q&A session, the control and experimental groups worked on the post-test questions on geography knowledge assessment.

This study used geographic thinking test questions with four indicators. The indicators were taken from four geographic concepts (spatial significance, patterns and trends, interrelationships, and geographic perspective). Each of the four indicators consists of five questions, so we had a total of 20 items. The 20 items were validated by experts comprised of experts in materials, learning, and assessment and evaluation. The pre-test and post-test were given to each control and experimental group in the three research subject schools. A correct answer to each question was worth 5 points, while an incorrect answer was worth 0 points, so a perfect score for the geographic thinking test was 100.

The data obtained were then analyzed using a paired sample t-test, and Cohen's d was used in measuring the effect size using a comparative analysis of test results in the experimental and control groups related to pedagogical significance and intensity of manipulation. The data were required to complete normality and homogeneity tests before conducting paired sample t-test analysis. Then a paired sample t-test was performed, and the effect size was evaluated. The formula used to assess the effect size in the paired sample t-test is as (1).

$$d = \frac{meanD}{SDD} \quad (1)$$

where, d is Cohen's d value; $mean_D$ is mean sample value; and SD_D is standard deviation value. The criteria of the effect size based on Cohen's d [31] are presented in Table 2.

Table 2. Effect-size

Effect-size	D
Small	0.2
Medium	0.5
Large	0.8

3. RESULTS AND DISCUSSION

The findings showed an increase in students' geographic thinking, indicated by an increase in the post-test average of 24.15 points (68.94) compared to the pre-test average (44.79). Performance comparisons during the post-test and pre-test showed that the experimental and control groups in the three schools improved due to learning geography through fieldwork-based blended learning. These results support the statement that geography can be learned through blended learning in the post-COVID-19 pandemic [22]. Blended learning in geography must not eliminate the essential components of geography, namely fieldwork activities.

Table 2. Paired sample statistic

Score	Mean	N	Std. Deviation	Std. Error mean
Pre-test	44.79	216	10.96	0.75
Post-test	68.94	216	14.86	1.01

Table 3 depicts the average score of geographic thinking performance. Geographic inquiry activities contribute to geography learning as an effort to improve geographic thinking. Through geographic inquiry, students not just listen, read, or memorize geographic information but participate in geographic activities, facilitating meaningful learning experiences. This finding is supported by Favier and Schee [32], that using geographic inquiry can optimize geography learning; results suggest that geographic inquiry can be used to improve students' geographic thinking. However, further investigation is needed on whether fieldwork-based blended learning without the GIVE application is sufficient for learning during the COVID-19 outbreak.

Paired sample t-tests were used to compare performance between the experimental groups that used mixed learning methods of fieldwork-based blended learning with the GIVE mobile app and the control groups that used mixed learning methods of fieldwork-based blended learning without GIVE. The statistical test shows that the significance value of Sig. (2-tailed) is 0.000 as presented in Table 4; this means that there is a significant difference between the experimental groups and the control groups. The research hypothesis has been answered, showing that GIVE influences students' geographic thinking; in other words, students who used the fieldwork-based blended learning with GIVE performed better than those who did not.

Cellular technology has been proven to support learning outside the classroom because of its many advantages [21], [27]. This research is different from previous studies whose findings were used to improve student geography learning outcomes, while this research shows that mobile applications designed with geographic inquiry to support fieldwork activities can develop students' geographic thinking. The development of a virtual learning environment for geography is based on nature. In this study, the environment focuses on the lithosphere in virtual fieldwork sites, which can be engaging and interactive [19], and not just a virtual laboratory [6], [20]. The virtual environment or field must be specially developed, with visualizations related to the lithospheric landscape to enable data collection during fieldwork.

Table 3. Summary of paired sample t-test analysis

Mean	Std. Deviation	Std. Error Mean	95% Confidence interval of the difference		t	df	Sig (2-tailed)
			Lower	Upper			
-24.14	17.59	1.19	-26.5	-21.78	-20.17	215	0.000

The effect size measurement results using Cohen's d formula are shown in Table 4. The effect size shows the value of Cohen's d (1.37), confirming that GIVE is included in the big category for increasing geographic thinking. This allows students to be actively involved in geographical activities arranged systematically to understand lithospheric phenomena because GIVE is prepared based on geographic investigations. GIVE is mobile and portable, making it easy to carry to fieldwork sites. This is also supported by the previous findings [33], that mobile technology improves students' ICT skills and their understanding of geographic content. In addition, the study results also show that students improve not only their understanding of geographic content but also geographic thinking.

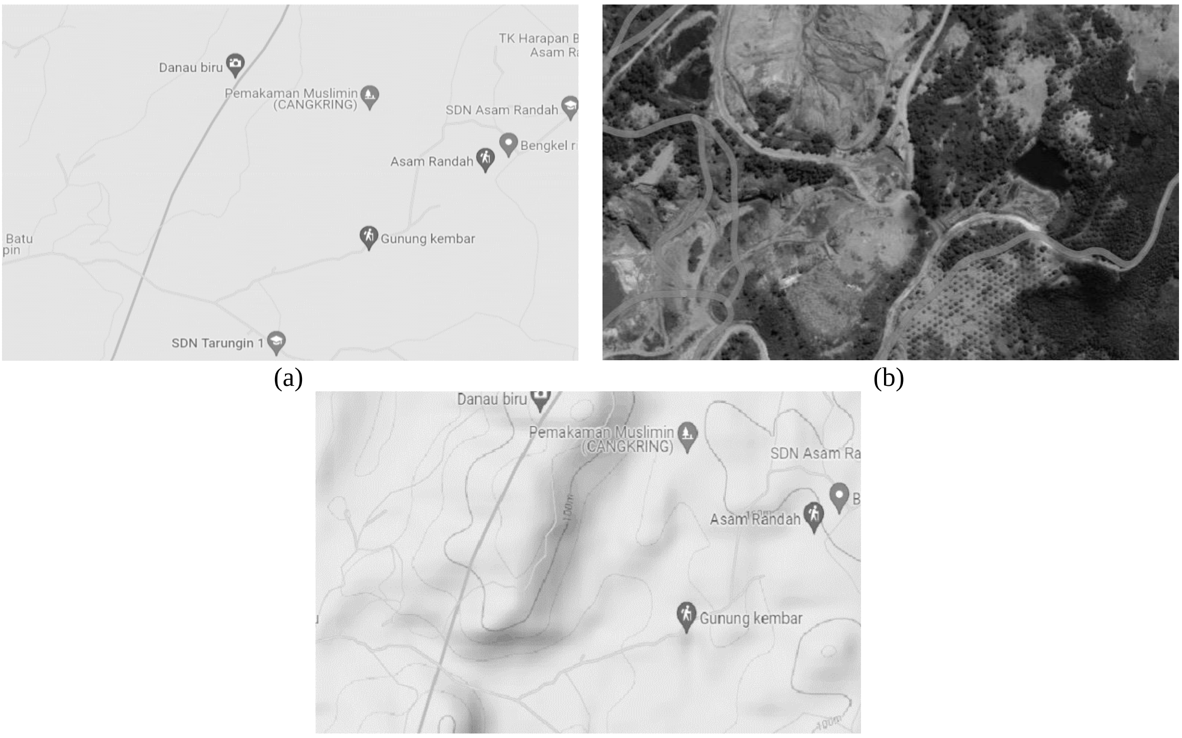
Furthermore, a more in-depth discussion on GIVE in fieldwork-based blended learning was conducted to improve students' geographic thinking. The experimental and control groups showed different results in the four indicators of geographic thinking as shown in Table 5. The experimental groups had higher mean scores for indicators of spatial significance and patterns and trends than the control group. Meanwhile, the control groups had higher mean scores on the interrelationships and geographic perspective indicators than the experimental groups.

Table 5. The average performance of the four indicators of geographic thinking

Groups	Post-test results on geographic thinking indicators (maximum 25)			
	Spatial significance	Patterns and trends	Interrelationships	Geographic perspective
Control	14.17	11.53	19.58	20.83
Experimental	20.14	21.76	15.19	15

GIVE can enhance geographic thinking better on indicators of spatial significance and patterns and trends. Before visiting the fieldwork site, the experimental groups were exposed to lithospheric content and digital maps in GIVE, which provided them with a visual experience and enhanced their spatial reasoning thinking. In contrast, the control groups only got a little visual experience because they only read about the lithosphere in textbooks. The experimental groups had the opportunity to explore the maps in GIVE sourced from Google Maps, allowing them to see indicators of patterns and trends using a wide selection of map modes ranging from satellite to terrain. The interactive map helped the experimental groups to understand patterns and trends better than the control groups; spatial significance requires students to determine the importance of a location within an area [34], which is difficult for students to understand without experience using interactive maps.

Integrating interactive Google Maps into GIVE helps students understand patterns and trends. Students in the experimental groups had more opportunities to access patterns of different geographic modes on the map than the control groups. This result is supported by the statement that learning through maps can increase geographic awareness [35]. In experimental learning theory, navigating a map in three modes is considered “reflective observation” as presented in Figure 2. This is important in the process that modifies meaning-making [28]. Students needed a moderator to understand the patterns they picked up by exploring the digital maps on GIVE. Due to “abstract conceptualization”, the tendency was that students’ abilities in the experimental groups were more pronounced than in the control groups. Students must develop an understanding that contextual conditions in geography can change over time and space, and therefore all knowledge is temporary and context-dependent [28]. Figures 2 (a)-(c) depicts the three map modes (satellite, standard, and terrain) embedded in the GIVE application.



(a) (b)

(c)

Figure 2. Three modes of a map in GIVE: (a) satellite, (b) standard, and (c) terrain

The control groups performed better than the experimental groups on the interrelationships and geographic perspective indicators. This happened because the control groups had the opportunity to visit the fieldwork location more frequently than the experimental groups for observation and data collection as shown in Figure 3. As a result, they spent more money and time than the experimental groups. The early observation experience is almost irreplaceable. The concept of interrelationships requires students to investigate the relationship between the environment and nature [15], causing increased involvement of students with the fieldwork site; after all, being in nature is not the same as doing it virtually. In addition, the control groups completed all assignments manually, so students had opportunities to analyze and solve real-world problems; this proved to be even more beneficial for students in terms of enhancing their geographic perspectives. Figure 3 shows students carrying out fieldwork at a rock outcrop location.

Fieldwork and other learning activities outside of the classroom provide students with valuable experiences. The experience of visiting local fieldwork sites enhances students’ understanding of the interrelationships between geographic components. The interrelationships between landscapes, the environment, and humans must be taught to students through learning outside the classroom [36]. Fieldwork-based blended learning based on Morris’ experimental learning model integrates the needs of a geographic content approach by visiting natural geosphere phenomena and using appropriate technology, resulting in more meaningful learning for students. This is due to the influence of various motor sensors and students’ feelings involved in learning experiences in real and virtual worlds, which calls “contextually rich” [28]. The findings are corroborated by previous study [37] stating that combining technology with fieldwork provides advantages in location recognition, data collection, and monitoring. The treatment we provide has more impact than the TTG learning model that has been done before [16].

Figure 3. Manual data collection by the control groups

Students in the control group had a higher average score for the indicator of geographic perspectives because they learned the real world through "active experimentation", which gives them the advantage of getting context-specific problems [28] and the ability to do it directly. However, the score of the experimental groups in the indicator of geographic perspectives was also quite good. Students in the experimental groups could also engage in "active experimentation", but they had to overcome certain constraints, such as dependence on other supporting software and internet connection.

Our study confirms the potential of a virtual environment close to the real condition of the natural lithospheric phenomenon. In the future, virtual environments will become an important tool for studying geography. This is because a teacher cannot provide a truly real learning experience due to several constraints, one of which is the distance between the school and the location of the existing lithospheric phenomena; for example, students in Indonesia cannot go and study the South Pole directly when discussing the topic of melting ice due to global warming. Students can get experiences in a virtual environment because they can be "immersively" present in locations that are rare and almost impossible to visit. According to the findings of this study, we believe that students' geography perspectives develop along with the increased quality of the virtual environment presented in geography learning.

4. CONCLUSION

The GIVE mobile application has shown pedagogical effectiveness in helping fieldwork-based blended learning to improve students' geographic thinking when studying the lithosphere. This app has a large effect size as well. GIVE is designed to enhance students' geographic thinking through geographic inquiry. This research shows that, although learning geography cannot be fully carried out online, hands-on learning in a real-world context remains an important method of learning geography. Virtual fieldwork sites remain important for students to support their readiness for fieldwork directly in the real world. This study concludes that geography must be studied in a blended learning environment so that students have the opportunity and experience of "doing" geography activities in developing geographic thinking. Furthermore, the future challenge for geography researchers and teachers is to create a more realistic virtual geographic environment. If it can be presented in learning, virtual environments can improve all indicators in geographic thinking, such as spatial significance, patterns and trends, interrelationships, and geographic perspective.

ACKNOWLEDGEMENTS

The authors thank the Rector of Universitas Negeri Malang for supporting this study through the PNBP fund as stated in Decree No. 4.3.13/UN32/KP/2021 concerning Dissertation Research Grant and the Decree No.18.5.60/UN32/KP/2022 concerning Dissertation Publication Grant.

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