Mobile Virtual Field Trip and Geography Education: Potential Exploration of Complex Problem Solving and Spatial Intelligence Capabilities

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Abstract—This study aims to determine the effect of M-VGFT media on students' Complex Problem Solving and Spatial Intelligence abilities. Quasi-experimental research with post-test-only group design method. The design used two experimental groups with a purposive or judgment sampling method considering the average class value. X.2 Social Science group (14 boys and 20 girls), X.3 Social Science group (17 boys and 17 girls), and X.4 Social Science (17 boys and 17 girls). The subjects of this study were first-year high school students in the even semester of the 2021/2022 academic year. Hypothesis testing using independent sample t-test to determine the effect of M-VGFT media on the ability of students' Complex Problem Solving and Spatial Intelligence in the subject of Geography on Volcanism. The results showed a significant influence between M-VGFT media on students' Complex Problem Solving Ability and Spatial Intelligence in Madrasah Aliah Negeri Baru. However, there are differences in the influence between male and female students on the two variables.

Keywords—mobile technology, mobile virtual field trip, complex problem solving, spatial intelligence

1 Introduction

1.1 Background

The development of mobile technology influences the use of learning media. Technology can simplify and facilitate the learning process of materials that require a more profound explanation [1], [2]. Mobile technology plays an essential role in students' social, emotional, and academic lives [3]. Tools in mobile technology that support students to be more productive and creative in generating ideas and solutions to the problems presented. Technological capacity improves the way of learning, interacting, and collaborating on the material in the learning. Materials considered difficult become easy if technology integration is applied in technology-based learning media [4].

Digital learning media is a form of technology integration to facilitate understanding and authentic experience of abstract material. The Covid-19 pandemic is an obstacle for students in getting field experience in Geography studies; however, virtual field trip technology can be a solution [5]. Students explore, determine methods, analyze, present problems [6] and perform spatial analysis can be facilitated by virtual technology by visualizing natural aspects of the field [7]. Digital media removes the limitations of the dimensions of space and time in learning [8] so that learning can be meaningful and provide new experiences. Changes in the current learning paradigm affect the competencies and capabilities that students must possess in response to the challenges of job requirements [9], one of which is the ability to complex problems solving.

Complex problem solving is students' ability to solve problems in a complex manner that did not exist before in real life. The challenges of learning geography in the future are full of decision complexity, problem and solution complexity, task complexity, and environmental uncertainty [10]; teachers and students must anticipate it. The ability to translate problems and create solutions to problems is trained in a contextual learning process. The ability of complex problem solving is appropriate if implemented in Geography learning because a comprehensive analysis is needed in studying geosphere problems [11], [12]. This will encourage the development of other skills, especially in students' Spatial-Intelligence.

Spatial intelligence is a critical component in learning geography. Spatial studies are the primary domain of geography [13]. Spatial Intelligence students tend to be sensitive to the surrounding environment [14], [15]. Studying geographical phenomena is closely related to complex problem solving and Spatial Intelligence, such as the ability to solve problems and analyze environmental conditions (space). Geography students must have these competencies to answer career and job challenges in the era of technological disruption. Two competencies can be realized with the help of Mobile Virtual Geosite Field Trip (M-VGFT) media.

The learning media that is currently developing during the Covid-19 pandemic is the M-VGFT. This media facilitates immersive learning experiences, discovering new things and learning in a virtually authentic environment, although not a direct substitute for field activities. This media will inspire and motivate students in learning Geography. M-VGFT can assist in learning activities outside the classroom (field trips) but cannot be carried out due to the Covid-19 Pandemic. M-VGFT is a digital visualization to support the implementation of field activities without having to leave the classroom [14], [15].

M-VGFT is an answer to maintaining the quality of Geography learning so that it does not reduce students' competencies and capabilities in learning during the Covid-19 Pandemic. Currently, the safety and security of students come first, thus requiring students not to go to the field to prevent the spread of the virus [5]. In addition, learning activities in the field require a lot of time and money so the M-VGFT can streamline learning activities.

This research aims to reveal in-depth the effect of M-VGFT on the ability of complex problem solving and Spatial Intelligence. M-VGFT is a 360-degree visualization of Mount Ijen Geosite supported by images, videos, and supporting information used to provide a detailed description of the geological heritage of Mount Ijen. The existence

of an M-VGFT can assist students in virtual field exploration in the study of volcanism (volcanic structure, volcanic formation, types of volcanoes, types of volcanic eruptions, magma movement, and volcanism results). In the Geography curriculum of SMA in Indonesia, mastery of volcanism is at the C4 cognitive level in bloom taxonomy (higher-order thinking skills).

1.2 Research questions

Research questions are presented in the form of research hypotheses (Ho). In addition, there are two research questions: whether there is a significant effect between the experimental group using M-VGFT media on the indicators of students' complex problem solving and Spatial Intelligence abilities.

2 Methodology of research

2.1 Research design

This quasi-experimental study used a posttest-only group design. The design used two experimental groups (X.2 and X.3 Social Science) and one control group (X.4 Social Science) with a purposive or judgment sampling method with consideration of the average class value (equivalent ability). X.2 Social Science group (14 male and 20 female), X.3 Social Science group (17 male and 17 female), and X.4 Social Science (17 male and 17 female). The subjects of this study were first-year high school students in the even semester of the 2021/2022 academic year.

The experimental group used the M-VGFT media with the Discovery Learning model. Meanwhile, the control group used the same model but used conventional media. The research location is Madrasah Aliyah Negeri Batu, East Java-Indonesia. The research subject is the study of volcanism (volcanic structure, volcanic formation, types of volcanoes, types of volcanic eruptions, magma movement, and volcanism results). Each class received a complex problem-solving and spatial Intelligence ability test after being given treatment.

Researchers chose schools based on the results of observations for three months. The results of the observations formulate the findings as follows; (1) Geography students at this school have an interest in technology in learning but are not accommodated due to the lack of digital pedagogic competence of geography teachers, (2) Facilities support the implementation of mobile virtual field trips that the school has, for example, computer laboratories, smartphone use policies, internet network with high bandwidth and the availability of head-mounted displays, and (3) the demands of students' competence and capability in mastering volcanism material are very high, this is based on 97 percent of students living in areas of active volcanoes.

2.2 Research procedure

This research step is adapted to instructional learning (learning activities) and M-VGFT media. The use of virtual media requires a VR Box as virtual glasses equipped with earphones to provide the same sensation as the actual condition.

Table 1. Instructional learning for the experimental group

Syntax	Learning Activities
Stimulation	▪ Apperception and learning objectives to equalize perceptions in the learning process. ▪ Simulation of M-VGFT. ▪ Grouping students into six groups with 5-6 students/group members.
Problem Statement	▪ Students observe the visualization of the Mount Ijen complex with a panorama of the M-VGFT media. ▪ Students identify volcanism and the impact of volcanism on life by virtual acceleration. ▪ Students formulate hypotheses.
Data Collection	▪ Students collect information to prove hypotheses about volcanism with the help of an M-VGFT.
Data Processing	▪ Students process data in groups.
Verification	▪ Presentation of the results of data analysis with the help of virtual evidence/findings to answer the hypothesis.
Generalization	▪ Teachers and students conclude from the results of field studies virtually.

Table 2. M-VGFT framework development and material content

Main System	Accessibility Feature	Material content
Storytelling	Content	Interactive Information Literacy and Involvement of Ijen Geosites as a result of the volcanism process
	Area	Geosite Mount Ijen
System	Head Mounted Displays	Verification and Exploration Process of volcanism in Mount Ijen area
	Cardboard	
Camera	Photo	Explaining evidence of volcanism in the Mount Ijen area
	Video	

2.3 Research data

The research data was obtained from the results of the post-test of students adjusted to the CPS and Spatial Intelligence indicators. The research instrument was used as ten questions (six multiple-choice and four descriptions) with Bloom cognitive levels C1-C4. Indicators of CPS from Mahendra (2020) and indicators of spatial intelligence from the National Research Council (2005). The instrument was tested for the validity of the questions (Pearson's product-moment, 0.000) and the reliability of the questions (Cronbach Alpha, 0.6). Data analysis used SPSS Statistics to test prerequisites and hypotheses [16]. The prerequisite test consists of a normality test (Kolmogorov

Smirnov) and a homogeneity test (one-way ANOVA). The results of the data analysis concluded that the data were normally distributed and homogeneous. Hypothesis testing using independent sample t-test.

3 Result

The results of hypothesis testing on RQ to see if H_0 is accepted or rejected. Hypothesis verification was obtained from the post-test scores on each indicator of complex problem-solving and spatial intelligence using the independent sample t-test. The results see in Table 3 and Table 4.

Table 3. independent t-test and mean of complex problem solving indicators

Complex Problems Solving Indicator	Mean		Sig. (2-tailed)
	Experimental Group	*Control Group*	
Identification of problems	5.00	4.11	0.01
Cultivating Positive Thoughts	16.29	11.14	0.00
Exploration of ideas	18.97	13.67	0.00
Evaluation	9.88	7.05	0.00
Execution	9.70	7.94	0.33
Re-Check	15.35	9.52	0.00
Total	75.20	53.47	0.00

Source: Research Data (2022)

Table 4. Mean and independent t-test indicator of spatial intelligence

Spatial Intelligence Indicator	Mean		Sig. (2-tailed)
	Experimental Group	*Control Group*	
Space Concept	23.16	15.44	0.00
Representation Tool	18.85	21.23	0.30
Reasoning	40.88	33.88	0.01
Total	80.47	70.58	0.01

Source: Research Data (2022)

Based on Table 3, students in the experimental group (75.20) have a higher average score when compared to students in the control group (53.47) on complex problem-solving variables. If analyzed in-depth on each indicator of complex problem solving, the majority of indicators obtained a significant value (0.05), and only the "execution" indicator (Sig. 2-tailed, 0.33) was not significantly affected. While in Table 4, the results of the spatial intelligence variable on each indicator also get a value (sig. 2-tailed) of 0.05, only on the indicator representation tool (0.30). The average value of the experimental group (80.47) while the control group (70.58). Suppose the value of sig is analyzed jointly between the ability of complex problem solving and Spatial Intelligence. (2-tailed) (0.00), it can be concluded that M-VGFT media influences complex problem solving and students' spatial intelligence.

4 Discussion

M-VGFT media can have a significant effect on complex problem-solving abilities. M-VGFT technology is a virtual reality technology that allows students to perform simulations with 3D visuals. M-VGFT provides an immersive experience because it seems to be directly involved in a natural environment [17], [18]. In the COVID-19 pandemic limiting students in outdoor study activities and field trips, M-VGFT is the right solution to overcome limitations [5]. The M-VGFT uses VR glasses and a headset with a safe and interactive 360 projection environment [19].

Using M-VGFT must be supported by appropriate instructional design to achieve learning objectives and outcomes. In this study, instructional learning refers to the discovery model syntax by measuring complex problem-solving and spatial abilities in geography. M-VGFT affects students' ability to identify problems through the stages of problem statements made by the teacher in the learning process [20]. Students explore the geological site on Mount Ijen to observe the morphology of the volcano and its constituent rocks by source material from volcanism [5].

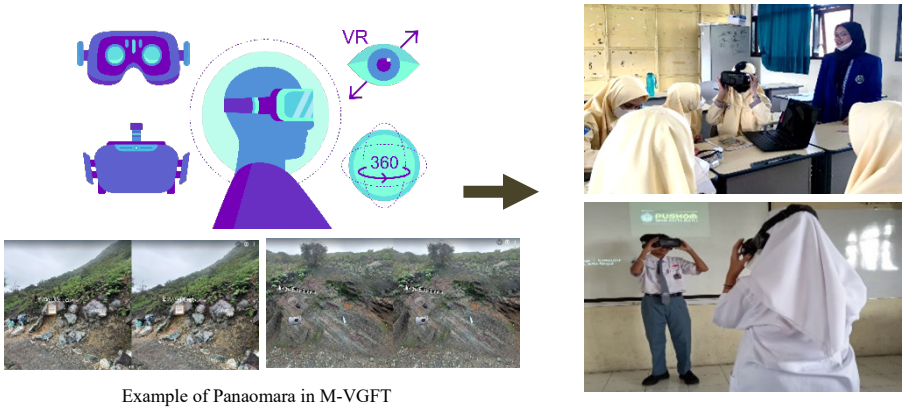

Fig. 1. Use of M-VGFT in volcanism studies on mount Ijen Geosite

M-VGFT develops positive thoughts, generates new ideas and evaluative abilities, and facilitates students to collect and process data and verify it virtually. M-VGFT is integrated with learning resources from scientific articles, infographics, research data on volcanic activities, and a map of the disaster-prone Ijen volcano. M-VGFT technology with various learning resources arouses students' curiosity [21], [22] and improves students' complex problem-solving abilities in studying volcanism in geosite areas.

M-VGFT media provides virtual field visits with complex multimedia support. Multimedia support is constructed based on the value of immersive learning experiences in geography [23], [24]. The immersive environment benefits field-based learning constrained by COVID-19 with the right instructional design and immersive technology support. Cognitive load and reflective thinking can provide two possibilities

(disruptive or beneficial) depending on the instructional design of immersive learning [25], [26].

A virtual environment facilitates social presence [27] and enhances reflection through eating interactions with peers [28]. Using M-VGFT individually in group activities to identify volcanism types and activities encourages students to collaborate and have meaningful interactions. In addition, with M-VGFT supported by google earth and google street view, students validate information (validity of information) based on virtual observations, and findings are disclosed in the presentation of results. See Figures 2 and 3.

Fig. 2. Virtual observation with M-VGFT and validation of finding data

Fig. 3. Presentation of the results of virtual observations and data validation with the support of technology geospatial applications

However, this study found that students were afraid or hesitant to make decisions, provide solutions, and account for the results of virtual studies through M-VGFT. This can be seen in the CPS for the execution indicator that does not meet the standard of statistical significance, which is interesting in this study. Virtual visits to explore and collect data cannot be separated from the level of student efficacy [29], [30]. The indicator illustrates that the higher self-efficacy, students tend to try and try to see complexity as a challenge. If self-efficacy is high, students tend to collect more data from various scientific sources to strengthen virtual findings with M-VGFT [29], [31].

Another finding revealed that the M-VGFT media positively influenced spatial intelligence variables in the concept of space and Geography deductive reasoning. M-VGFT is constructed and integrated with geospatial technology to provide realistic visualization incorporating the functions of spatial queries. Thus, multidimensional spatial information can be found easily with VR visualization with "head-mounted display" glasses [32], [33], [34]. The study of volcanism in geography learning is concrete; for example, in the sub-study of volcanic structures, volcanic formations, and volcanism results, 3D visualization is urgently needed.

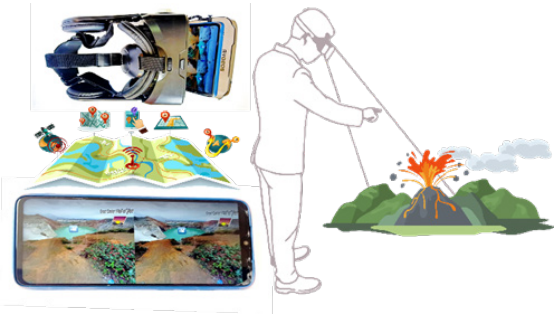

Fig. 4. Illustration of geospatial technology integration with M-VGFT

VR visualization provides tangible benefits for learning Geography, especially in studying volcanic volcanism. The VR technology in M-VGFT stimulates sensory (visual observation style) to obtain meaningful learning and motivation from virtual observations, but teachers need to consider student workloads. The immersive environment in the M-VGFT constructs episodic memory from the study of volcanism, allowing students to get a learning experience from virtual facts involving memories of certain events, situations, and experiences. The immersive environment provides a substantial life experience that theoretically adapts learning activities and performance rather than just listening and understanding.

5 Conclusion

This study revealed the effect of M-VGFT media on the ability of complex problem-solving and spatial intelligence of geography students. M-VGFT media helps students construct their abilities and capabilities through virtual visual observation activities with the help of virtual glasses. This experiment broke the gap, learning geography during the covid-19 pandemic that limited outdoor activities. However, this study has limitations on the research variables. The scope of the research only focuses on indicators of Complex Problem Solving and Spatial Intelligence variables. The complex Problem-Solving variable significantly affects 5 (problem identification, fostering positive thoughts, exploring ideas, evaluating, and checking back) indicators, and 1 (execution) indicator is not affected. While the ability of spatial intelligence 2 (space concept and reasoning) indicator has a significant effect and 1 (representational tool) indicator has no effect. Therefore, suggestions for future researchers can research the use of M-VGFT media with other variables, such as immersive experience and others.

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