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Development of Virtual Geography Laboratory to Improve Cognitive Learning Outcomes and Spatial Capabilities Social Sciences Education

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ABSTRACT

This project aims to develop a website that functions as a virtual laboratory for studying geography topics that is suitable for use, as well as testing its effectiveness on cognitive learning outcomes and spatial abilities. The research uses the Borg and Gall development model, which is then summarized and divided into three main activities: introduction, development, and testing. Subject selection was based on the cluster random sampling technique. The subjects consisted of Class Learning outcome data was collected using questionnaires, interviews, pretests and posttest, analyzed using descriptive statistical tests and Mancova inferential statistics. Research Results: 1) the development of a geographic virtual laboratory is suitable for use according to material experts and received the "very good" category, while according to media experts it received the "good" category; 2) students gave a strong response to the implementation of the virtual geography laboratory; 3) there is a significant difference between initial abilities and cognitive learning outcomes and spatial abilities; and 4) there are no significant differences between two schools that implement virtual geography laboratories with cognitive learning outcomes and spatial abilities.

***Keywords*:**

Geography Virtual Laboratory; Learning Outcomes; Spatial.

ABSTRAK

Tujuan dari proyek ini adalah untuk mengembangkan website yang berfungsi sebagai laboratorium virtual untuk mempelajari topik-topik geografi yang layak digunakan, serta menguji efektivitasnya terhadap hasil pembelajaran

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kognitif dan kemampuan spasial. Penelitian menggunakan model pengembangan Borg and Gall yang kemudian dirangkum dan dibagi menjadi tiga kegiatan utama yaitu pendahuluan, pengembangan, dan pengujian. Pemilihan subjek berdasarkan teknik cluster random sampling. Subjek terdiri dari Kelas X di SMA Plus Al-Fatimah Bojonegoro sejumlah 66 siswa yang mempunyai karakteristik wilayah perkotaan, dan SMAN 1 Singgahan Tuban sejumlah 68 siswa yang mempunyai karateristik wilayah pedesaan. Data hasil belajar dikumpulkan dengan menggunakan angket, wawancara, pretest dan posttest, dianalisis menggunakan uji statistik deskriptif dan statistik inferensial mancova. Hasil Penelitian: 1) pengembangan laboratorium virtual geografis layak digunakan menurut ahli materi dan mendapat kategori "sangat baik", sedangkan menurut ahli media mendapat kategori "baik"; 2) mahasiswa memberikan respon yang kuat terhadap penerapan laboratorium virtual geografi; 3) terdapat perbedaan yang signifikan antara kemampuan awal dengan hasil belajar kognitif dan kemampuan spasial; dan 4) tidak terdapat perbedaan yang signifikan di antara kedua sekolah yang menerapkan laboratorium virtual geografi dengan hasil belajar kognitif dan kemampuan spasial.

***Kata kunci*:**

Laboratorium Virtual Geografi; Capaian Pembelajaran; Pembelajaran Spasial.

1. Introduction

The rapid evolution and emergence of information and computer technologies have greatly affected education (Supahar & Widodo, 2021). The increasing prevalence of computer-based learning material and the internet has been linked to the development of multimedia content. This includes various integrated media such as video, text, animations, and virtual reality (Winkelmann et al., 2017). The rapid development of multimedia content has created digital-based virtual laboratories (Abdelmoneim et al., 2022). Students do not need to have any real-world contact experience to use these environments. They can use them as educational tools for research projects. In developed nations, virtual laboratories have started to be widely used in schools, providing an easier way to learn and conduct research. The rapid emergence and evolution of computer technologies have greatly affected the field of education. The increasing number of fast internet connections and the decreasing cost of computing have made it a necessity for millions worldwide. The ease of use and accessibility of software further support this trend.

Students can perform various tasks through virtual laboratories, such as evaluations, case studies, and problem analysis (Al Hassan, 2020). They can also interact with learning materials and equipment (Yanto et al., 2022). This environment allows them to explore further knowledge by performing experiments and becoming more independent (Wang & Kumar, 2022). Rather than providing experience in a traditional laboratory setting, virtual laboratories offer a breakthrough that enables students to conduct practicum activities. They are a combination of advancements in communication and information technology. Additional devices, such as electronic gadgets, are required to operate a virtual lab (Potkonjak et al., 2016). Moreover, students can interact and learn in virtual laboratories without being limited by space and time constraints (Purwati et al., 2015).

The creation of virtual laboratories should focus on geography materials, as this discipline involves the practical applications of geospheric phenomena. According to Shaherani et al. (2022), geospheres are objects related to humans and are the main focus of geography. Prasetya et al. (2018) suggest that to teach geography effectively, the materials should be presented in a way that allows students to visualize and understand geosphere phenomena. This means that the materials should be expanded beyond the classroom to include activities that can be conducted outside the classroom (Prasetya et al., 2022). Exploring the real environment is one of the most important factors when developing innovative learning tools. This can be achieved by creating virtual laboratories that allow students to study geosphere phenomena in digital space. Unfortunately, constructing such facilities can be very expensive and time-consuming. In addition to creating virtual laboratories for digital classrooms, researchers also suggest that the materials should be packaged in a way that allows easy transportation.

In construction-related learning experiences, virtual technologies can be utilized to enable the creation of artifacts (Tseng et al., 2020). Various real-world phenomena, such as those in the social and physical world, can be presented through video-based programs. This allows students to discuss and analyze these phenomena in an online environment. The learning process must encourage collaboration among students (Radianti et al., 2020). Collaboration in asynchronous discussions is a form of social presence and supports learning experiences in virtual laboratory environments.

Through virtual laboratories, students can enhance their environmental learning by accessing resources designed to help them study in various settings (Girvan & Savage, 2019). This type of learning material can also help them improve the accuracy of information by allowing them to study objects in detail. Additionally, it provides an opportunity to participate in learning activities that are more engaging than traditional classroom methods (Shaherani et al., 2022).

A virtual laboratory utilizes a platform with interactive features and functions similar to those of real facilities (Boulton et al., 2018; Muñoz-Cristóbal et al., 2017). Computers are used in virtual laboratories to simulate and manipulate the real world in a digital space, where students can perform simulations and experiments (Ackermann, 2004). Through digital technology, the real world is selected, reduced, and packaged into a representation that preserves important data**.** This ensures that the information presented in virtual reality and the real world remains consistent (Edwards, 1998).

Virtual laboratories provide students with an environment designed to represent real-world phenomena. Through this learning resource, students can develop their attitudes toward nature and expand their knowledge of various subjects, such as geography and social sciences (Prasetya et al., 2020). In addition to discussing the various aspects of the environment, activities related to it can also be integrated into geography learning. Prasetya et al. (2021) explained that environmental conditions are often addressed in terms of both the social and natural environment. There are three ways to introduce geographic material to students: lectures, field studies, and media use. Teaching geography using materials related to geospheric phenomena can improve quality if appropriately applied in class.

A virtual geography lab is being developed to provide students with an environment representing the real world. This media type allows them to develop their learning flexibility and improve their concrete understanding of the subject.

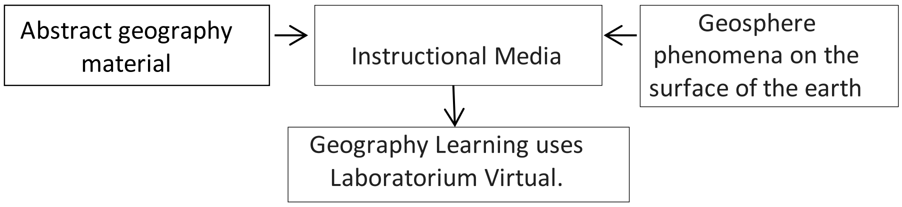

Figure 1. Geography virtual laboratory bridging abstract material and phenomena in the real world

This study aims to develop a proper geographic virtual laboratory and analyze the student's responses after using it. It also explores the differences in spatial abilities and cognitive learning outcomes between learners with varying abilities.

Conventional geography learning usually relies on textbooks and lectures, which are less visual and interactive. This can cause difficulty in understanding abstract concepts such as geomorphological processes, weather patterns, or geological formations. Virtual laboratories allow geographic material to be presented more interactively and visually through digital maps, animations, and 3D simulations. This can help students understand abstract concepts more tangibly and practically. Virtual laboratories can make learning more interesting and varied by using technology. It can increase student motivation and make geography learning more interesting, leading to better learning outcomes.

2. Methods

2.1. Type of Research

This research uses a research and development (R&D) approach. The product produced as a virtual geography laboratory will be developed into a viable product. Then its level of effectiveness will be tested in terms of cognitive aspect learning outcomes and spatial abilities. The research uses the concept of research and development to develop an integrated geographic virtual laboratory that can be used in schools. It presents the various steps of the development process and then divides them into three main activities: introduction, development, and testing. Borg and Gall (2007), is a model used to develop a virtual geography laboratory because this model is specifically designed to obtain certain learning outcomes (special abilities and cognitive learning outcomes). In this model, each element in the stages of media development always refers to achieving the expected learning objectives.

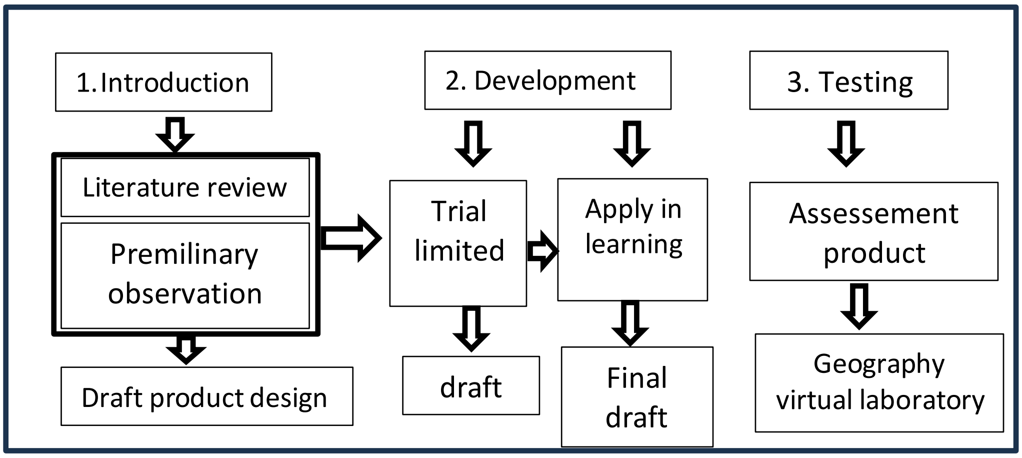

Figure 2. Schematic of research and development flow (adapted from Borg & Gall, 2007))

Figure 2 explains how the product development scheme starts from planning in the form of review literature and preliminary studies/observations, which will produce a product design draft. The next step is to conduct a limited trial, which will be revised into a final draft after implementing the learning. After the final draft is implemented in learning, a product assessment will be carried out to create a virtual geography laboratory that is suitable for use. The steps in development are summarized in three main activities: introduction, development, and testing.

2.2 Research Subjects

The research subjects in this research were chosen randomly and carried out at two high schools in East Java, namely SMA Plus Al Fatimah Bojonegoro (66 students), which has the characteristics of an urban area, and SMAN 1 Singgahan, Tuban (68 students), which has the characteristics of a rural area.

2.3 Data Collection and Analysis

The collected data was analyzed using various tools, such as assessing spatial skills and cognitive aspects. Posttest and pretest results were then analyzed to determine if they met the necessary prerequisites. The findings were then analyzed using the mancova assessment.

3. Results and Discussion

3.1 Introduction

The creation of the virtual laboratory was conceptualized based on initial observations about the subject in high school and literature studies. The draft's creation stage begins with selecting the geography lesson's objectives and the materials and methods used in the course. The virtual laboratory will feature various scopes and materials related to integrated geography. Some include geospheres, such as the atmosphere, lithosphere, and hydrosphere; disaster and village spatialities; social geography; and environmental geography.

The creation of virtual laboratories involves several main sections. These include the preparation of geographical information such as maps and images, the selection of a software platform, the creation of tasks and activities, and the final editing. Virtual laboratories can be designed using Indonesian and English depending on the needs analysis carried out by the users and teachers. The goal of a virtual laboratory is to provide a comprehensive view of the material's systematics. This includes the title of the material, the learning objectives, the experiments, and the feedback.

Figure 3. The Initial View of The Virtual Geography Laboratory (website link)

3.2 Development

The media produced for the development of a virtual laboratory in East Java's northern region has been handled by various experts. These include material and media experts. Once the products have been validated, the researcher will receive media revisions based on their input. The lab's virtual environment has been developed through video-based presentations, animations, and documentaries.

The goal of the project was to develop a website that would serve as a virtual laboratory for the study of geographical topics. The materials were created through various activities, such as maps and learning media. A conceptual framework for developing materials has been established during the design phase. This was then translated into a product ready to be utilized according to the project's objectives.

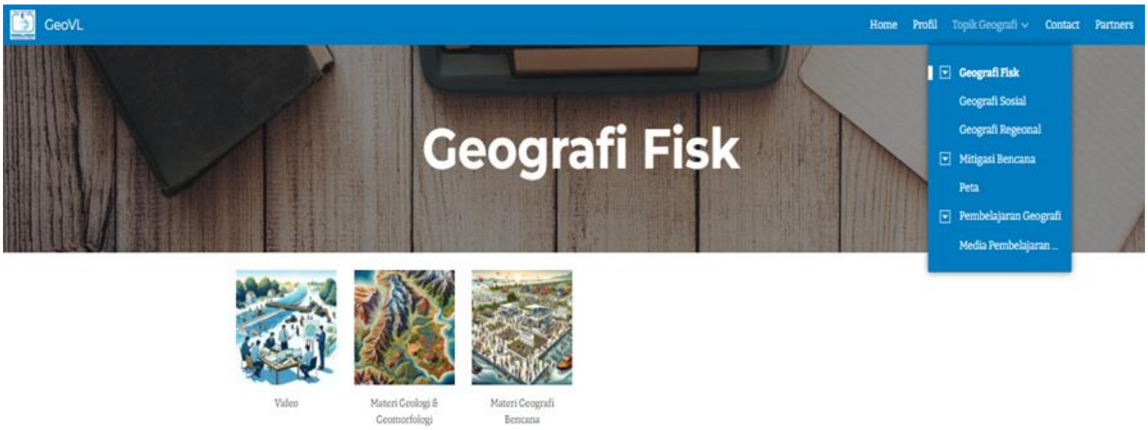

Figure 3. The layout of the seven main topics of the geography virtual laboratory

https://sites.google.com/unesa.ac.id/geovilab (website link)

3.2.1 Design Validation

Two expert lecturers at the Department of Geography Education, Universitas Negeri Surabaya, Indonesia, validated the virtual geography laboratory design. The experts in this research are Prof. Dr. Ketut Prasetyo, M.S, as a material expert, and Dr. Sri Murtini, M.Si, as a media expert. This expert assesses each component in the virtual geography laboratory per the guidelines for evaluating the suitability of learning media. The feasibility of geographic virtual laboratory media, which experts have evaluated, is presented in Table 1.

Table 1. Recapitulation of virtual laboratory feasibility assessment results by experts

Material Aspects	**score**	**Media Aspect**	**score**
learning objectives formulated correctly	3	effectiveness, efficiency, and practicality of using a geography virtual laboratory	3
learning objectives have relevance to geography material in schools	3	easy maintenance and management of equipment (maintainable)	3
interactivity	2	visual (layout design, typography, colors)	1
contextuality and actuality	3	moving media (animation)	3
material depth	2	interactive layout (navigation icons)	
systematic/sequence/clear, logical flow	3	compatibility	2
correct presentation of material, analysis giving examples, practices, and exercises	3	reusable	1
suitability between assessment tools and established learning objectives	3	Its use is easy to operate (usability)	3
ease of understanding	3	communicative	2
accuracy of using learning strategies	2	clarity and attractiveness of material in text form	3
total score	27	total score	21
score average	2,7	score average	2,1
criteria	very good	criteria	good

Table 1 shows that material experts provide "very good" criteria, and media experts provide results with "good" criteria so that virtual geography laboratory products are suitable for use as computer-based learning media. Material experts gave a score of 3 to most components, but the components of interactivity, depth of material, and accuracy of using learning strategies got a score of 2. Likewise, media experts gave a score of 3 or 2 to most of the components, except for the visual and reusable components, which were only given a score of 1.

3.2.2 Design Revision

The design the experts had validated was then revised according to input from the two experts (Table 2).

Table 2. Revised Geography Virtual Laboratory Design

Material Aspects	Revision	Media Aspect	Revision
Clarity of learning objectives	Include specific learning objectives	Usability (easy to use and simple operation)	Adding home to the interface
Material depth	The need for the development of integrated geographic material	Visual (layout design, typography, colors)	• The position of the button writing on the main menu is uniform • The text on the language selection display is differentiated
Clarity of description, discussion, examples, simulations, and exercises	Add figures and use command sentences in the instructions for doing the practicum		

Based on Table 2, material experts' input to clarify the learning objectives component should be written specifically so that students know the learning objectives that must be achieved. The geography topic submenu in the form of text needs to be expanded because it needs more attention from students. Include something else in the material depth component, namely the need to develop integrated geography material, which is hoped will lead to interdisciplinary understanding in students. Input from experts conveys that it is better to use a menu and be accompanied by figures to show clarity of description.

Several inputs from media experts also became guidelines for revising the development of a geography virtual laboratory. The "Home" menu is important as the main description of using the geographic virtual laboratory. There is no need to provide music because it can interfere with the user's hearing, so experts recommend removing it not to disturb the concentration of users of the virtual geography laboratory. In the visual component, the text will appear when the main menu button is highlighted and selected. Still, it turns out that the text on each menu is in a different position, so experts recommend making the position of the text uniform.

3.2.3 Geography Virtual Laboratory Trials

The geography virtual laboratory design, assessed by experts and revised, was then tested on class X students at SMA Plus Al Fatimah, Bojonegoro, with a sample of 30 students on a limited-scale trial. Student response data stated the acceptance of geography virtual laboratory as a computer-based learning media if it scored≥ 2.51. Student responses were taken using a questionnaire accompanied by criticism and suggestions as a guideline for revising the geography virtual laboratory, which was given after learning to use the geography virtual laboratory. The results of student responses are shown in Table 3.

Table 3. Recapitulation of Student Responses on Limited-Scale Trials

Criteria	Score Range	∑ students who respond	Percentage
Very supportive	3,25 < skor ≤ 4	21	70
Supportive	2,50 < skor ≤ 3,25	8	27
Less Supportive	1,75 < skor ≤ 2,50	1	3
Not Supportive	1 < skor ≤ 1,75	0	0
Number of students with very supportive and supportive criteria		29	97

Based on Table 3, students gave 97% "very supportive" and "supportive" responses to the virtual geography laboratory. The number of respondents with a "very supportive" response was greater than respondents with a “supportive”. Of the 30 respondents, only one student responded, "not very supportive." The description above explains that the virtual geography laboratory was well received because it scored≥ 2.51. Furthermore, table 4 presents the results of student responses in the form of averages and criteria.

Table 4. The Mean Score For Each Item of Student Responses on Limited-Scale Trials

Response	Average Score	Criteria
the media can attract interest	3,40	very supportive
learning objectives have been covered in the media	3,30	very supportive
students can easily apply the operation of the media	3,20	supportive
new material can be assisted through the application of media	3,40	very supportive
media design raises student interest	3,50	very supportive
there is up-to-date information and guided exercises in the media	3,15	supportive
students' learning motivation can increase after using the media	3,60	very supportive
independently or media groups can be used	3,10	supportive
media has effectiveness, efficiency, and practicality	3,15	supportive
media arouse to study the material further	3,50	very supportive
number	33,3	
total average score	3,33	very supportive

The average score for each student response item mostly shows a "very supportive" response. However, responses 3, 6, 8, and 9 show supportive responses. Of the ten student responses, the acceptance of the geography virtual laboratory as a computer-based learning medium was rated "very supportive" because the total average score of 3.33 has achieved an acceptance indicator (score ≥ 2.51).

Several students provided input and criticism based on the questionnaire results, which became material for consideration when revising the product. Input and criticism from students is that the background display is less varied, and the number of evaluation questions, as many as 10, is considered a little. A few students are unsatisfied with the information conveyed, even though the information delivery in the geography virtual laboratory is quite easy to understand.

3.2.4 *Implementation*

After the development continued with the application of learning in class X High School, in this stage, the implementation of learning was carried out for high school students in geography subjects using a geography virtual laboratory. The learning implementation was applied to two high schools, SMA Plus Al Fatimah Bojonegoro, with 66 students, and SMAN 1 Singgahan Tuban, with 68 students.

The evaluation is done once the learners have completed the virtual lab course. The objective of the evaluation is to gain insight into improving the student's performance in the course and determine the extent to which they can master the subject. It also aims to identify the problems that the learners face and recommend possible changes in the learning plans.

3.3 *Testing*

Testing is carried out after the learning activity model takes place by distributing test instruments (pretest and posttest) to determine students' cognitive abilities and spatial skills. Cognitive abilities are developed with a description test of 10 questions representing each indicator of geography material in class X. Spatial abilities are developed based on a thematic map to strengthen analytical skills in space. Table 5 shows statistical descriptions of learning outcomes and spatial abilities at SMA Plus Al Fatimah and SMAN 1 Singgahan.

Table 5. Descriptive Statistics on learning outcomes and spatial abilities

School	Data	Mean	Std. Deviation	N
SMA Plus Al Fatimah	learning	76,3485	10,54732	66
SMAN 1 Singgahan	outcomes	75,1029	8,87414	68
Total		75,7164	9,71752	134
SMA Plus Al Fatimah	spatial abilities	89,5455	92,58745	66
SMAN 1 Singgahan		80,5588	8,11923	68
Total		84,9851	65,13895	134

After learning by implementing a virtual geography laboratory, tests are carried out that test students' cognitive abilities (learning outcomes) and spatial abilities. Based on table 5 shows that the average score for learning outcomes and spatial abilities at SMA Plus Al Fatimah is 76 and 89, with a sample size of 66 people. The average scores for learning outcomes and spatial abilities at SMAN 1 Singgahan are 75 and 80, with a total sample of 68 people.

The differences in cognitive learning outcomes and spatial abilities between students who studied using the virtual geography laboratory at SMA Plus Al Fatimah and SMAN 1 Singgahan were analyzed using MANCOVA statistical tests. Two assumptions must be met in Mancova: the assumption of homogeneity of covariance and the assumption of multivariate residual normality. Table 6 presents the results of testing assumptions in Mancova.

Table 6. Mancova Assumptions Test

Assumption	P-value	Information
Covariance Homogeneity	0,138	homogenous
Normality of cognitive learning outcomes	0,670	normal
Normality of spatial ability data	0,164	normal

The test results in Table 6 show a P-value of 0.138 because the P-value> 0.05 (0.138 > 0.05) indicates that the covariance between groups is homogeneous, so the assumption of covariance homogeneity is fulfilled. The second assumption is the assumption of multivariate residual normality, meaning that the residuals (errors) of the Mancova model are expected to be distributed normally. This assumption is tested using the Kolmogorov-Smirnov Test. Residuals spread normally if the P-value>0.05. The test results in Table 6 show that the P-value is 0.670 and 0.205. Because the P-value > 0.05 (0.670 and 0.205 > 0.05) indicates that the residual normality assumption is met, both Mancova assumptions are met. Therefore, the Mancova results are suitable for use and interpretation. Table 7 presents the results of the Mancova test calculation with pretest (initial ability) as the covariate variable.

Table 7. Tests of Between-Subjects Effects

Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	,758	203,262[b]	2,000	130,000	,000
	Wilks' Lambda	,242	203,262[b]	2,000	130,000	,000
	Hotelling's Trace	3,127	203,262[b]	2,000	130,000	,000
	Roy's Largest Root	3,127	203,262[b]	2,000	130,000	,000
pretest	Pillai's Trace	,177	13,997[b]	2,000	130,000	,000
	Wilks' Lambda	,823	13,997[b]	2,000	130,000	,000
	Hotelling's Trace	,215	13,997[b]	2,000	130,000	,000
	Roy's Largest Root	,215	13,997[b]	2,000	130,000	,000
schools	Pillai's Trace	,007	,480[b]	2,000	130,000	,620
	Wilks' Lambda	,993	,480[b]	2,000	130,000	,620
	Hotelling's Trace	,007	,480[b]	2,000	130,000	,620
	Roy's Largest Root	,007	,480[b]	2,000	130,000	,620

a. Design: Intercept + pretest + schools
b. Exact statistic

Table 7 shows the results of tests of between-subjects effects (Tests of Between-Subjects Effects) carried out in this study. Multivariate covariance tests (MANCOVA) were applied for analysis. The influence of different variables on students' cognitive learning outcomes and spatial abilities was assessed using this test. The multivariate test values displayed are Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root. The value of that variant shows the effect of each variant. The results on "Intercept" show a significant effect of the initial average (Intercept) on cognitive learning outcomes and spatial abilities, with a very small significance value ($p < 0.000$). Table 7 shows that the initial ability (pretest) and the dependent variable cognitive learning outcomes and spatial ability have a significance value of 0.00, which means a sig. < 0.05. This means there are differences in initial knowledge (pretest) with cognitive learning outcomes and spatial abilities. Meanwhile, virtual geography laboratory learning was implemented at SMA Plus Al Fatimah and SMAN 1 Singgahan schools, with the dependent variables of cognitive learning outcomes and spatial abilities having a significance value of 0.620, which means a sig. > 0.05. This means no differences exist in schools implementing virtual geography laboratories with cognitive learning outcomes and spatial abilities.

3.4 Geography Virtual Laboratory Feasibility

Material experts evaluate the feasibility of virtual geography materials through various assessment criteria, such as clarity, relevance, and contextuality. On the other hand, media experts evaluate the virtual lab's viability by considering its technical requirements, efficiency, and software construction. After validating a geography virtual laboratory, its use can be determined based on its educational purpose. Material evaluators rated the virtual lab "very good," while media experts gave it a "good" category. In their feedback, experts noted that virtual laboratories can be utilized in education with minor changes. Sugiyono (2017) Specified that the main requirement when it comes to implementing learning tools is the ability of validators to provide viable learning solutions.

A material validator must study geographical information to comprehensively integrate it into other themes. A virtual lab for geography can be conceptualized with different themes, such as disaster mitigation, social geography, physical geography, and maps. A virtual lab aims to help students develop their knowledge of geographical objects and materials. By combining different themes, the virtual lab can help pupils improve their comprehension of geographical study topics separate from formal and material studies. Due to the nature of the two studies, they cannot be separated (Goudie, 2017). For instance, Goudie's method of combining physical and human aspects is used to study phenomena in an integrated manner (Meijles & Stoffelen, 2021). In addition, in geography education, the emphasis is on integrating social and physical aspects in an environmental analysis (Massey, 2016).

The virtual lab for geography was developed using web-based technology. It features interactive pages with text, video, and virtual environments. According to Emigh & Herring (2005), a web-based lab can help pupils participate in practicums on their own. It can also give them the necessary tools and resources to conduct their activities independently. This type of virtual laboratory can be accessed through an internet connection, which makes it very flexible (Muzana & Hasanah, 2018).

3.5 Student Response to The Application of Geography Virtual Laboratory

About 96% of the students indicated they were very supportive of the virtual laboratory concept and its use in computer-based learning. This shows that the virtual environment can be used as a medium for learning. For students, the first experience using a virtual geography lab is very important in generating interest and improving their performance. Geographic material can be made to look realistic by using a computer. According to Ayoubi and Faour (2018), using a virtual laboratory to practice their theory can allow them to see and experience practical objects, according to Zaturrahmi et al. (2020), the ease of using virtual laboratories can influence the acceptance of this medium among users. Virtual laboratories provide a beneficial learning experience. They can help students continuously search for new knowledge by allowing them to practice their theories (Dobrzanski & Honysz, 2010).

The students' positive response to the virtual geography lab demonstrates its ability to be used efficiently, effectively, and cheaply. It aligns with the recommendations of Tamami and Dwiningsih (2020), who believe that such environments are beneficial because they do not require expensive equipment or materials. They also reduce the limitations of traditional laboratories. In addition, according to Arif et al.(2021)Virtual laboratories can help students who are slow to understand the material because they can allow them to improve their skills more effectively. Bajpai and Kumar (2015) They also believe that these environments are interactive, allowing students to carry out practicums.

The results of the virtual lab activities can generate curiosity among students, which can spark their interest in the subject being discussed (Tüysüz, 2010). According to Yuanita and Sumargo (2014) Studying, virtual laboratories can help students improve their understanding of the material and complete their assignments. It can also boost their motivation to learn and prevent them from making assumptions since the materials are presented in a way that makes it hard for them to understand.

3.6 Cognitive Learning Outcomes And Spatial Abilities Between Students Who Have Different Initial Abilities

Virtual geography classrooms can help improve spatial abilities and cognitive learning. They can also help students understand the material that they need help to explain verbally, according to a study by Hamida et al. (2013), virtual laboratories can affect how well students learn. In addition, the research conducted by Purwati et al. (2015) and Goldschmidt and Bogner (2016) Revealed that implementing such programs can improve students' academic performance. The findings show that the interventions in these learning environments can significantly enhance students' analytical and understanding skills.

Students can improve their passive learning and stimulate their thinking through virtual laboratories. This is according to Huang's study (2004), which found that these environments can help improve students' motivation and conceptual understanding. In addition, the results of cognitive tests revealed that the learning environment can improve the student's academic performance.

According to Munawarah (2014), virtual laboratories can help improve students' cognitive understanding by allowing them to identify and apply materials based on geographical features. They can also motivate them to conduct interactive experiments and develop their spatial abilities (Tatli & Ayas, 2012). The findings of this study highlight the importance of establishing virtual laboratories in geography education to help improve students' spatial abilities and cognitive learning outcomes.

3.7 Cognitive Learning Outcomes and Spatial Abilities Between Students Who Implemented Virtual Geography Laboratories at SMA Plus Al Fatimah and SMAN 1 Singgahan

The study results revealed that the spatial abilities and cognitive learning outcomes of SMAN 1 Singgahan and SMA Plus Al Fatimah students were similar after they established virtual laboratories. However, the two schools had distinct geographical characteristics. For instance, while SMAN 1 Singgahan is rural, SMA Plus Al Fatimah is in the city center. Mukhsin (2019) Noted that there is inequality between villages and cities regarding the mastery of communication and information technology, as cities are more likely to have internet services. This issue also exists in schools within urban and rural regions, as the development of infrastructure and facilities related to technology in these areas is faster than in villages (Kurniawatik et al., 2021; Oktavianoor et al., 2016).

Although there is a digital divide between Indonesia's urban and rural regions regarding information technology, the two schools that used virtual laboratories had similar outcomes regarding improving students' spatial abilities. The students of the two schools could use and access the virtual laboratories' learning media without any issues. In addition, according to Chan & Fok (2009), virtual laboratories can benefit students already at a higher level of education. Besides improving students' spatial capabilities, virtual laboratories can also help teachers improve the learning outcomes of their subjects.

A virtual geography laboratory can be utilized as a medium for students to learn about geography in high school (Wijayanto et al., 2018). In addition to being used in class, these types of laboratories should also be conducted in the field so that students can study geosphere phenomena (Wulandari, 2012). One of the biggest challenges people face when it comes to implementing direct learning within the field of geography is the time and energy involved. This can be solved by creating a virtual geography laboratory to provide a more realistic experience.

Short-term learning outcomes (pretest and posttest) are more important than evaluating long-term retention of knowledge and skills acquired from virtual laboratories. Further research is needed to assess the long-term retention of knowledge and skills gained from virtual laboratories. The virtual laboratory shows its effectiveness. This research has yet to compare physical laboratories or direct learning in the field to evaluate the advantages and disadvantages of each. Virtual laboratories can impact a person's cognitive and spatial skills and cognitive and spatial abilities. These include problem-solving skills, critical thinking, and attitudes toward learning geography. However, this research has not examined how virtual laboratories affect non-cognitive learning outcomes.

4. Conclusion

The results of the research and discussion show that (1) the development of geography laboratory products is suitable for use in geography learning in high schools, with an assessment in the "very good" category. The material expert suggested slight revisions, especially regarding the depth of the material, which covers seven main topics (physical, social, regional geography, disaster mitigation, mapping, geographic learning, and learning media). Material experts suggest improving the ease of use of the virtual geography laboratory. (2) students' responses after using the virtual geography laboratory responded with "very supportive" learning because the virtual geography laboratory was able to arouse interest and clarify learning activities. (3) There was a significant increase in initial knowledge of cognitive learning outcomes and spatial abilities. Visualization of geosphere phenomena and abstract concepts can be made more concrete with virtual geography laboratories, and this media can be used at flexible times and low costs. (4) no significant difference exists between students who implemented the virtual geography laboratory at SMA Plus Al-Fatimah and SMAN S1 Singgahan with cognitive learning outcomes and spatial abilities. Even though the two schools have different regional characteristics (rural and urban), they have the same ability to master information technology to implement virtual geography laboratories well.

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