Jurnal Pendidikan Geografi:
Kajian, Teori, dan Praktik dalam Bidang Pendidikan dan Ilmu Geografi, 29(1), 2024, 15-27
ISSN: 0853-9251 (Print): 2527-628X (Online)
DOI: 10.17977/um017v29i12024p15-27

Unlocking the potential of the geography laboratory as a 21st-century skill-learning hub

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Paper received: 30-06-2022; revised: 14-01-2023; accepted: 01-08-2023

Abstract

Acquisition of 21st-century skills can be achieved through the use of supporting facilities and infrastructure. In the study of geography, the laboratory functions as a learning tool that significantly improves teaching and learning activities. This research identifies and describes the potential for geography-based laboratory learning for management priorities and future development design. For this reason, this research uses mixed methods and descriptive analysis. Held in the Geography Department, Faculty of Social Sciences, State University of Malang. The population in this study consisted of Geography Department students and laboratory managers, while the sample was selected purposively from the class of 2019, totalling 84 students. Primary data was collected through structured interviews with students and in-depth interviews with geography laboratory managers to determine the potential for laboratory development over the last 5 years. Furthermore, this research has secondary data, namely laboratory equipment inventory data. Data analysis was carried out through SWOT analysis. The analysis results show that the geography laboratory consisting of Soil Geography, Geology, Cartography, Geographic Information Systems, Population Geography laboratories has quite large development potential. Conditions in each laboratory require development strategies. The development strategy includes: 1) planning, 2) procurement, 3) inventory, 4) storage, 5) arrangement, 6) utilization, 7) maintenance, and 8) disposal.

Keywords: potential; geography learning; laboratory

1. Introduction

Quality of education relies on various aspects, including the infrastructure that supports the learning process. Similarly, the attainment of 21st-century skills requires standard facilities and infrastructure. Laboratories constitute a pivotal educational facility with a significant role in helping students comprehend scientific concepts and cultivate the demanded skills in the era of 21st-century (Burghardt, Ferdinand, Pfeiffer, Reverberi, & Romagnoli, 2021; Emda, 2017; González-Pérez & Ramírez-Montoya, 2022; Nyangko, Karo, & Hamdani, 2014). Further, the benchmark of a laboratory's quality is its laboratory accreditation (Kanitvittaya, Suksai, Suksripanich, & Pobkeeree, 2010). However, Nyangko et al. (2014) described that schools and universities still lacks of proper laboratory facilities and infrastructure.

Consequently, the quality of a laboratory must be enhanced. As reported by a number of studies, such as Ismiyanti, Windasari, Vivin, and Aziz (2021) which identified the advisability and optimalization of natural science education laboratory. Meanwhile, Peniati and

Purwantoyo (2013) discussed the development design of school laboratory; Sani (2012) characterized the development of a physic laboratory; Isnarto, Abdurrahman, and Sugianto (2017) specified the development of need based laboratory; Nurhasanah and Deliani (2013) characterized the strategy of laboratory development; and Murtini, Sumaryati, and Noviani (2014) reported the development of integrated entrepreneurship laboratory.

The existing research has offered valuable perspectives on improving the quality of laboratory facilities. However, to date, no research has employed SWOT analysis for identifying the potential and development strategies of laboratories, which could serve as the foundation for laboratory development strategies. Hence, this study addopted SWOT analysis for identification of a more comprehensive guideline in optimizing laboratory potentials and effective development strategies to enhance laboratory-based learning.

Following the aforementioned discussion, this study analyzes the potential of laboratory-based geography learning. The results are anticipated providing the illustration and prioritization of the geography laboratory management and development design. thus, it generates effective geography laboratory development strategy based on the demand of world of work and progression of students' geography-related skills.

2. Method

This research employed a mixed-method approach and descriptive analysis. Descriptive research can be conducted using quantitative data collection method (Sumarmi, Kurniawati, & Aliman, 2020; Zellatifanny & Mudjiyanto, 2018). This research was carried out in the Department of Geography, Faculty of Social Science, Universitas Negeri Malang. The research population was Geography Department students and Laboratory Managers, while the sample was selected using purposive sampling. This sampling technique was carried out in the class of 2019 because this class is the one who will often use laboratories based on the Geography curriculum in 2022. The total sample was 84 students. Primary data were collected through structured interviews with the students, as well as in-depth interviews with geography laboratory managers to identify the potential laboratory developments over the last five years. This research was further substantiated by secondary data in the form of laboratory equipment inventory records.

In addition, the SWOT analysis has been used to identify the strategic planning across various management applications (Helms & Nixon, 2010). The SWOT analysis involves comparison of positive and negative factors impacting a particular project which further categorized into internal and external strengths (Table 1). However, the application of SWOT analysis also present challenges, including its lack in providing strategic direction. Therefore, in this study, the SWOT analysis was carried out aligning with expert opinions (Helms & Nixon, 2010). Determining the rating in SWOT uses a Linkert scale, namely 1-4. The weight and rating results are obtained from expert adjustment. Both of these data analyses were employed to determine management priorities and design strategies for the enhancement of geography laboratory potentials, aligning them with work requirements and the development of geographical skills.

Table 1. Matrix of SWOT

SWOT Analysis			
External Audit	Internal Audit		
	Oppurtunities	Strengths	Weakness
		SO	WO
	Threats	ST	WT

Source: Sumarmi et al. (2020)

3. Results and Discussion

3.1. Potential of the Geography Department Laboratory through SWOT Analysis

The geography laboratory at Universitas Negeri Malang holds a critical role in supporting geography education. This education facility explicitly aims for imparting a comprehensive understanding of various phenomena occurring on earth's surface, with their spatial variations. Besides, the pedagogical approach in geography learning is thoughtfully adjusted to align with students' cognitive development across different educational levels. This specifically tailored approach ensure the comprehensible and accessibility of the learning. Primarily, the central aim of geography education is to cultivate students' comprehension and intellectual growth concerning spatial organization and phenomena on the earth's surface.

In accordance with these principles, a well-equipped laboratory carry a pivotal role in the success of geography education. Consequently, the development of Geography Labolatory is essential for its maximum utilization. The geography laboratory consists of Land Geography, Geology, Cartography, Geographic Information Systems, Population Geography and Geography Education Media laboratories. The conditions in each laboratory are very different. The Soil Geography, Geology, Cartography, Geographic Information Systems, Population Geography laboratories already exist and are already in use, while the Geography Education Media Laboratory is in the development stage to lead to artificial intelligence. Further, the process of development necessitates a meticulous analysis to assess the facility's effective utilization. Thus, in this study, we adopted the SWOT analysis as it offers the capacity to explore the strengths, weakness, opportunities, and threats in relation to the geography laboratory progression. The results of SWOT analysis are presented in Tables 2 and 3.

The garnered data were adopted for geography laboratory, with x and y representing IFAS and EFAS (Juliana, Monoarfa, & Jarianti, 2020). The x of 2.3 was gathered from subtracting the strength by the weakness, while the y of 1.65 was garnered from subtracting opportunities by the threats. Accordingly, the quadrant I was (2.30 and 1.65), as illustrated in Figure 1.

Table 2. Results of SWOT Analysis on Internal Factors (IFAS)

Internal Factors (IFAS)				
Strengths (S)		Weight	Rate	Score
1	Geography laboratory consists of six sections (Geography of Soil, Geology, Cartography, Geographic Information Systems, Population Geography, and Geography Education Media)	0.4	4	1.6
2	The geography laboratory is equipped with survey equipment to meet the specific work requirements	0.4	3	1.2
3	The geography laboratory offers training programs for enhancing students' capacity	0.2	4	0.8
4	The geography laboratory facilitates both indoor and outdoor learning experiences	0.25	3	0.75
5	Natural laboratory is provided for the instruction of both physical and social geography	0.3	3	0.9
6	The geography laboratory provides service for soil physics and water quality analysis	0.3	3	0.9
Total			20	6.15
Weakness (W)				
1	Geography laboratory face limitations on human resources	0.3	4	1.2
2	The laboratory management processes remain predominantly manual	0.25	4	1
3	There has been no website to disseminate information	0.3	3	0.9
4	The physical space allocated for the geography laboratory should be expanded	0.25	3	0.75
Total			14	3.85
X = Strengths-weakness		2,3		

Table 3. Results of SWOT Analysis on External Factors (EFAS)

External factors (EFAS)				
Opportinities (O)		Weight	Rate	Score
1	Geography laboratory development by formulating the services related to the geography science.	0.2	3	0.6
2	Advancement of digital geography laboratory	0.3	3	0.9
3	Development of Geography Education Media Laboratory, which is currently absent in Indonesia	0.25	3	0.75
4	The issuance of laboratory certifications due to the limited presence of ISO-certified laboratories, which could serve as exemplary reference laboratories	0.1	3	0.3
Total			12	2.55
Threats				
1	The limited number of administrators which possibly hinders the effective management towards ISO certification, given the presence of six laboratories sections	0.2	3	0.6
2	Other higher education institutions have started developing Geography Laboratories for educational purposes; therefore, certification is urgently required	0.1	3	0.3
Total			6	0.9
Y = Opportunities-Threats		1.65		

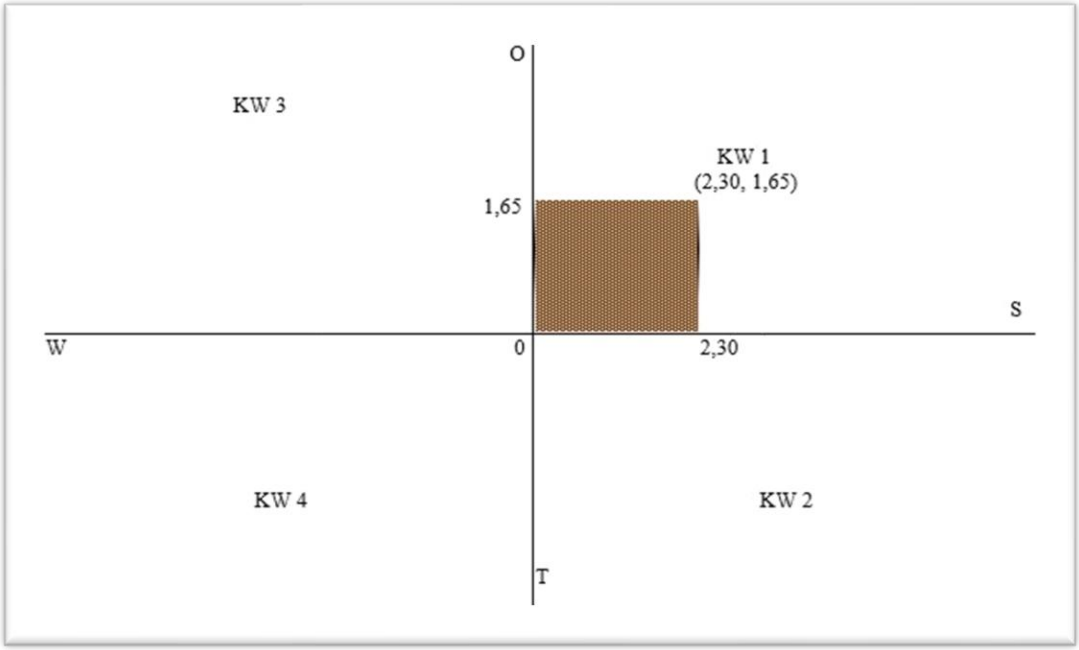

Figure 1. Quadrant Classification of SWOT analysis

SWOT analysis is commonly categorized into four distinct quadrants, labeled explicitly as quadrants I, II, III, and IV (Juliana et al., 2020). Each of these quadrants represent different alternative strategies for effective management. From the data, the geography laboratory is plased in quadrant I, frequently acknowledged as SO (strength-opportunities) or white area, suggesting the potential and opportunities for laboratory development. Consequently, this quadrant demands the implementation of proactive growth-oriented policies, such as the formulation of a comprehensive strategic blueprint for optimizing the geography laboratory's role as a proficient hub for laboratory-based learning for students' effective education.

In addition, quadrant II (strengths-threats) pertains to the attempts for establishing a laboratory model for other higher education institutions. This quadrant emphasizes the need for alignment between management strategies and the laboratory's strengths. For instance, initiatives should be directed at enhancing the laboratory's excellence to lead and inspire other educational institutions. Quadrant III or WO (Weaknesses-Opportunities), centers on human resource development. Therefore, this quadrant requires the laboratory development strategies to be oriented toward capitalizing on existing opportunities while addressing inherent weaknesses. This strategy may involve the addition of high-quality personnel to enhance laboratory management and utilization. Quadrant IV, denoted as WT (Weaknesses-Threats), focuses on the needs for integrated management approach based on ISO standards in the laboratory development process. This approach aims to address internal weaknesses and confront external threats more effectively. Collectively, these four quadrants offer invaluable direction for advancement of the geography laboratory based on its specific conditions and desired objectives.

The results of the SWOT analysis situating the geography laboratory in quadrant I, so it is essential to take tangible actions to realize the predetermined strategic goals. This necessitates the formulation of a comprehensive roadmap that outlines the specific geography laboratory developmental steps, as illustrated in Figure 2. Further, the realization of this

roadmap potentially aligns the geography laboratory's advancement with its inherent potential, thereby resulting in a profound impact on the geography learning process and the cultivation of 21st-century competencies among students.

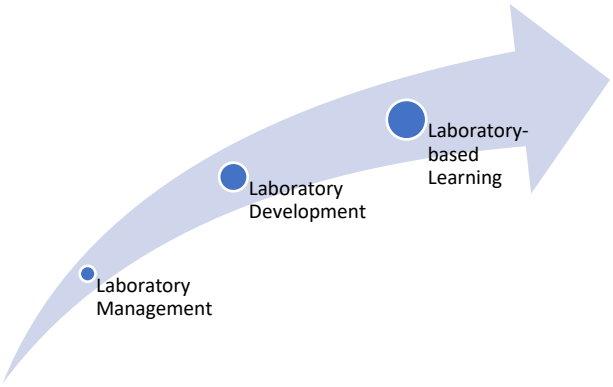

Figure 2. Roadmap for Geography Laboratory Development

The initial point of the roadmap lies in the laboratory management, a comprehensive process that encompasses planning, organization, as well as equipment and facilities allocation and regulation. This set of processes carries crucial roles for the education processes, including teaching, research, observational studies, training programs, and scientific investigations (Nurhadi, 2018). Additionally, laboratory management also optimizes the achievement of organizational objectives following the predefined roadmap for the Geography Department Laboratory (Lee & Dale, 1998; Nurhadi, 2018). Therefore, to ensure a substantial and meaningful learning experience for students, effective laboratory management practices becomes imperative. Further, the laboratory management process also entails eight fundamental components, including planning, procurement, inventory control, storage, organization, utilization, maintenance, and disposal. These components are essential for the geography laboratory development strategy, specifically for enhancing the efficiency and effectiveness of laboratory-based learning experiences.

3.2. Laboratory Development Strategy for Laboratory-based Geography Learning

3.2.1. Planning

The management of a laboratory initiates with the planning phase, for assessing the current state and identifying potential growth and improvement. In specific, planning carries the fundamental role in establishing a comprehensive procurement of laboratory facilities, including the essential educational resources and infrastructure, facilitating the seamless learning process in the laboratory environment. Excellent planning process ensures effective and efficient compliance of the laboratory's resources and infrastructure within the predefined time frame.

Ideally, a geography laboratory should exist six different laboratory components, including the Soil Geography, Rock Geography, Cartography, Geographic Information Systems, Population Geography, and Geography Education Media. These laboratory components have been earmarked for further development for transforming them into vibrant centers for

laboratory-based geography learning. A comprehensive outline of the geography laboratory planning is presented in Table 4.

Table 4. Planning for Geography Laboratory

No	Laboratory	Usage		Requirements for Planning
		Current state	Planning	
1	Soil Geography	Analysis and practice-based laboratory	An ISO-based Soil Analysis Laboratory	Procurement of equipment following SNI standards
2	Rock Geography	Laboratory practicum on physical properties of rocks	Mineral Analysis Laboratory based on Good Laboratory Practice (GLP)	Procurement of additional instruments for assessing the mineral composition of rocks
3	Cartography	Cartography practicum	Laboratory for cartography practicum	Replacement of cartography equipment to align with technological advancements
4	Geographic Information Systems (GIS)	Practicum using Geographic Information System	Laboratory for GIS data analysis and processing	Procurement of software that aligns with technological advancements
5	Population Geography	Practicum in population geography	Laboratory for geography data analysis and processing	Digitalization of population geography laboratory
6	Geography Learning Media	Peer teaching practicum	Laboratory for Geography learning media	Digitalization of geography education laboratory

The geography laboratory strategic development plan has been formulated based on the comprehensive analysis of the curriculum implemented in the Geography Department, involving collaborative discussions with stakeholders. Besides, the planning is substantiated by a needs assessment and determined budget allocation from the department (Barroy, Blecher, & Lakin, 2022; Tažiková, Struková, & Kozlovská, 2023). This underscores the imperative for planning to thoroughly accommodate the existing requirements within the department.

3.2.2. Procurement

The procuring of necessary resources and infrastructure is critical in realizing the preconceived plans. According to Ridwan (2022) procurement involves the systematic provisioning of essential goods and the execution of tasks. An effective procurement system adopts the Good and Clean Governance, as elucidated by Sitompul (2022). By steadfastly upholding this principle, the procurement procedure guarantee the quality and quantity of laboratory facilities alignment with the devised plans, facilitating effective learning process. In particular, the geography laboratory tailors its equipment procurement to cater to its specific needs. The inventory for equipment procurement in the geography laboratory is presented in Table 5.

Table 5. Procurement and Placement of Instrument in Geography Laboratory between 2017-2020

No	Instrument	Year	Laboratory
1	Drones	2017	Lab. Aerial
2	Total station	2017	Lab. Aerial and Lab. Terrestrial
3	Theodolite	2017	Lab. Aerial dan Lab Terrestrial
4	Geoelectric	2017	Lab. Hydrography
5	Spectrophotometry	2017	Lab. Pedo-Geomorphology
6	Distillation apparatus	2017	Lab. Pedo-Geomorphology
7	Drone	2018	Lab. Geospatial dan Modelling
8	Polaris microscope	2019	Lab. Pedo-Geomorphology
9	Rock Cutting Machine	2019	Lab. Pedo-Geomorphology
10	Geodetic GPS	2019	Lab. Aerial dan Lab Terrestrial
11	Hand anemometer	2019	Lab. Aerial dan Lab Terrestrial
12	Thermohygrometer	2019	Lab. Pedo-Geomorphology
13	Chemistry Cabinet	2019	Lab. Pedo-Geomorphology
14	Computer	2019	Lab. Geospatial dan modelling
15	Weather station	2019	Lab. Pedo-Geomorphology
16	Geodetic GPS	2020	Lab. Aerial
17	Fix wing	2020	Lab Aerial

3.2.3. Inventory

Inventory management contains the systematic record of assets and infrastructure held by the laboratory. This process involves the organized listing and cataloging of items, following established guidelines (Nurmayuli, 2022). Essentially, it contains three central stages, namely recording, coding, and reporting (Iskandar & Yanuar, 2023). The Geography laboratory should routinely conduct inventory management in every semester, for documenting all of its assets in the state-owned asset management application. This practice serves as quality control process for the laboratory's equipment, aligning with the principles promoted by Mentzer, Stank, and Esper (2008).

3.2.4. Storage

Storage procedure is critical to maintain the optimum condition of equipments ensuring their readiness for immediate use. Nurhadi (2018) described that effective storage follows specific principles, including the necessity to shield equipment from potential damaging factors, systematic administrative procedures for each storage unit, and the periodic execution of inventory assessments. The geography laboratory has conscientiously embraced storage protocols following the established standards. For instance, cameras and drones are securely housed in a dry cabinet to guarantee their preservation and operational readiness.

3.2.5. Organization

Systematic organization process presents excellent potential for stimulating students' intrinsic motivation for learning. From a psychological perspective, the methodical arrangement of laboratory equipment possibly grows students' innate curiosity and passion for academic exploration (Nurhadi, 2018). Their learning interest progresses following the structured laboratory environment that engenders a sense of comfort and engagement during the educational process (Herrington & Nakhleh, 2003; Kubat & Dedebali, 2018). Besides, orderly and conducive physical setting and the arrangement of laboratory resources

contributes significantly to enhanced learning outcomes among students (Kubat & Dedebali, 2018). Besides, the laboratory instrument arrangement also simplify the experiment and discussion conducted by students. The laboratory space arrangement in the Geography Department is illustrated in Figure 3.

Figure 3. Space Arrangement of the Geography Department

3.2.6. Usage

The principles of effectiveness and efficiency should guide the utilization of laboratory resources. Effectiveness ensures that the application of laboratories aligns seamlessly with the educational objectives established within the Geography Department (Kandamby, 2019). Meanwhile, efficiency relates to the utilization of laboratory infrastructure and resources to mitigate potential damages and losses (Utomo & Ibadurrahman, 2022). For enhancing the effectiveness and efficiency of the laboratory in the Geography Department, the most recent approach has been adopted, including the implementation of a specialized website platform, facilitating remote accessibility and administration. The display of Geography Department Laboratory website is presented in Figure 4. The laboratory website functions to make it easier for users to find out about the facilities in the geography laboratory. Users can also view equipment rental and training facilities at the geography laboratory. The website can be accessed at http://lab.geografi.fis.um.ac.id/.

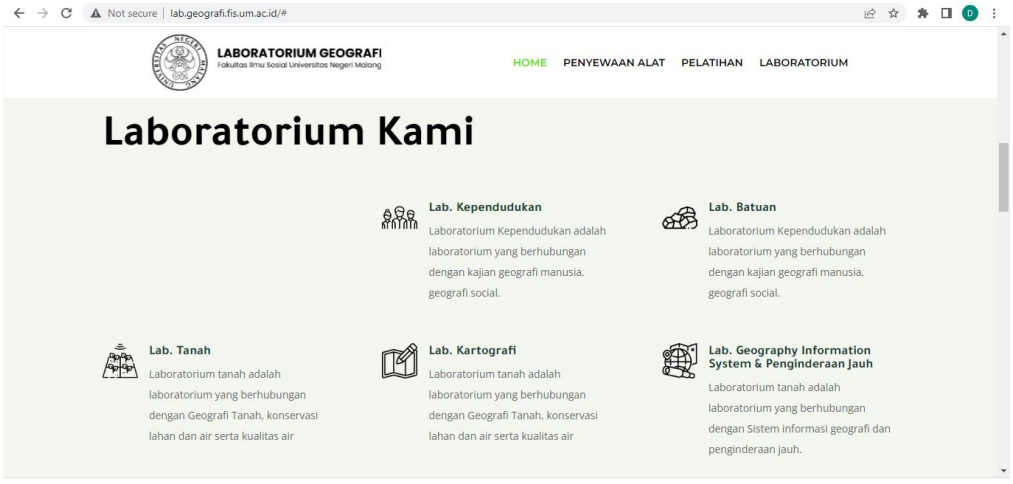

Figure 4. Website of Geography Laboratory

3.2.7. Maintenance

The maintenance of the laboratory is strategically designed to achieve multiple objectives, with the primary aim to enhance the overall performance and functionality of the laboratory while concurrently minimizing the potential for damage to essential equipment and infrastructure. Additionally, these maintenance programs serve the purpose of upholding the general tidiness and visual appeal in the laboratory surroundings. Consequently, it significantly contributes to optimizing cost-effectiveness in maintenance programs. The maintenance stages are presented in Figure 5.

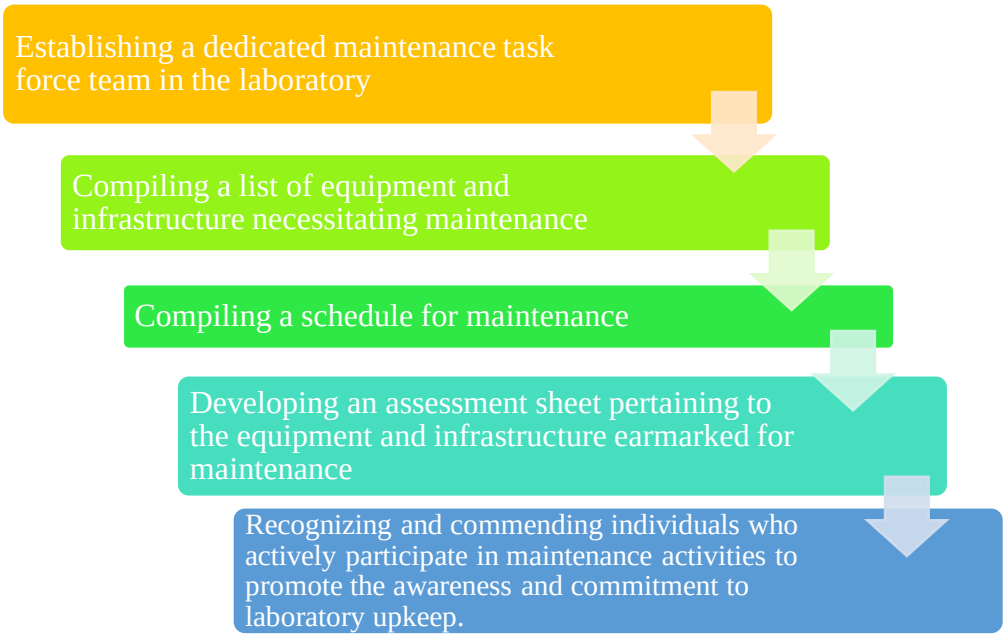

Figure 5. Stages of Maintenance

3.2.8. Disposal

Disposal constitutes the systematic removal of items in the inventory of an institution, guided by established protocols. There are two fundamental purposes for the act of disposal. First, to mitigate potential losses incurred through the maintenance of assets. Second, to relieve the responsibilities associated with inventory management from the institution. The disposal procedure contains a number of well-defined steps, consisting of: 1) annual selection of disposed goods by considering the future needs; 2) consideration of disposal factors from their financial value; 3) compilation disposal planning; 4) creation of draft of notification for the disposed goods; 5) conduct auctions, donations, or responsible disposal practices; 6) the disposal process is conducted under the supervision of higher-ranking authorities, and 7) prepare a detailed report, documenting the execution of the disposal procedure.

In addition, the devised development strategy for the geography laboratory is utilized as the fundamental for an innovative learning model. This innovative learning model is anticipated to facilitate students' experience of laboratory-based learning, offering them authentic experiences. The model becomes a pioneering example that seamlessly combines laboratory-based learning approaches with technology devices, such as the use of websites, to enhance the effectiveness and efficiency of the learning process. The primary focus of procurement, organization, maintenance, and disposal of facilities, as well as the improvement of laboratory-based learning quality, is to create an inspirational learning hub in the laboratory. Further, it also aims to facilitate the progression of students' 21st-century skills, particularly their critical thinking and environmental awareness. The laboratory development model is anticipated to be adopted by other institutions as a benchmark for innovative laboratory development. The geography laboratory development model is illustrated in Figure 6 for reference.

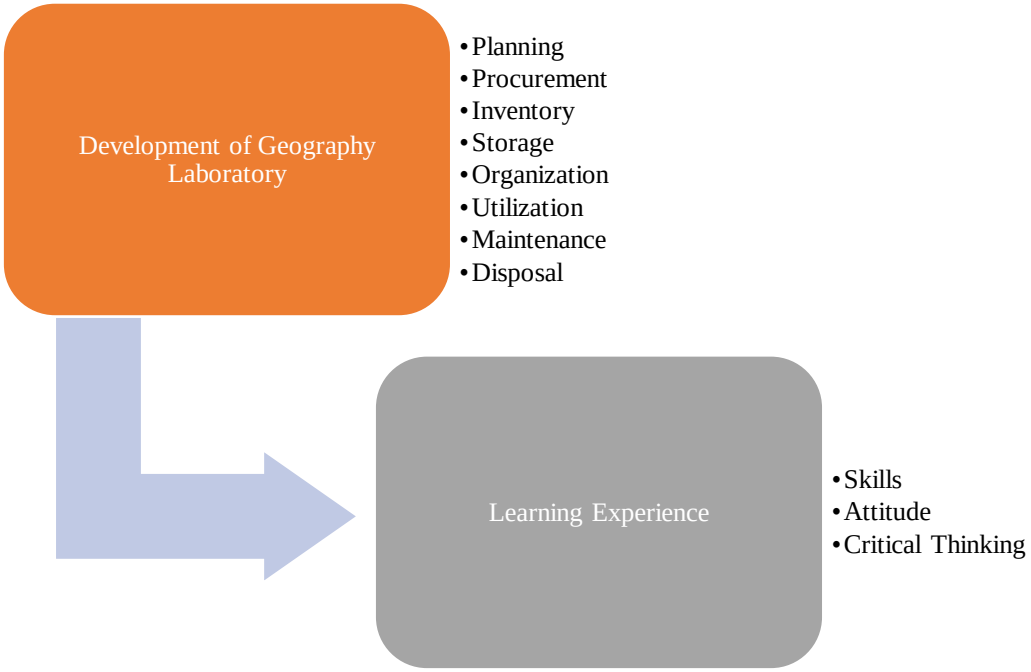

Figure 6. Development Model of Geography Laboratory

4. Conclusion

A laboratory serves as a space facilitating a group of individuals engaging in a wide spectrum of activities, such as research, observation, training, and scientific testing. From the SWOT analysis results, an established education laboratory can serve as a role model for other universities that aim to develop a laboratory with an integrated ISO-based management approach. The development strategy encompasses the following stages: 1) planning, 2) procurement, 3) inventory, 4) storage, 5) organization, 6) utilization, 7) maintenance, and 8) disposal. The long-term objective of establishing such a laboratory for educational purposes is to ensure the provision of a dynamic learning environment that imparts knowledge but also values empathy and collaboration. It fosters the skills to formulate collective decisions and critical thinking skills among learners.

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